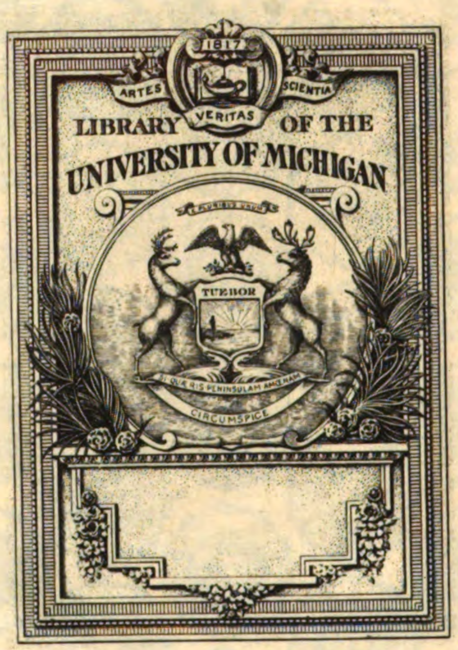

1817
ARTES
VERITAS
SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
CIRCUMSPICE

Industrial Engineering

with which is consolidated

Industry Illustrated

Volume 85

January to December, 1927

McGRAW-HILL PUBLISHING COMPANY, INC.
10th Avenue and 36th Street
NEW YORK

INDUSTRIAL ENGINEERING

INDEX TO VOLUME 85

January to December, 1927

GENERAL INDEX

PAGES BY MONTHS

January	1	to	44
February	45	to	100
March	101	to	148
April	149	to	196
May	197	to	244
June	245	to	300
July	301	to	348
August	349	to	396
September	397	to	444
October	445	to	500
November	501	to	548
December	549	to	600

•Indicates illustrated article

General

*Indicates illustrated articles

•Indicates illustrated articles

*Indicates illustrated articles

AUTHORS' INDEX

•Indicates illustrated articles

•Indicates illustrated articles

*Indicates illustrated articles

Volume 85 New York, January, 1927 *Number* 1

G. A. VAN BRUNT
Editor
D. H. BRAYMER
Consulting Editor

INDUSTRIAL ENGINEER

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

A. J. WHITCOMB
Contributing Editor
F. E. GOODING
G. H. FAIRBANKS
Associate Editors

Contents

Departments

Something About Ourselves

READERS of INDUSTRIAL ENGINEER may be interested to know that this publication was founded by George Worthington in New York, in 1882, the first issue appearing on February 15th of that year under the name of the *Review of the Telephone and Telegraph.* It was published twice a month for one year under that name, which was then changed to *Electrical Review,* and thereafter appeared weekly. Mr. Worthington remained as Editor until his death in 1892. Charles W. Price and William A. Hovey became Associate Editors in 1886, Mr. Hovey retiring a year later. Mr. Price succeeded Mr. Worthington and continued as Editor until 1922.

In 1908 *Electrical Review* was moved to Chicago and the *Western Electrician,* published there, was merged with it. A. A. Gray was Managing Editor for a number of years, retiring in 1917. In 1912 *Electrocraft,* a monthly published in Detroit, was merged with *Electrical Review* and in 1918 *Electrical Engineering,* a New York monthly publication, was also purchased and merged.

On January 1, 1922, *Electrical Review* was purchased by the McGraw-Hill Publishing Company and beginning with the January, 1922, issue the name was changed to the *Electrical Review and Industrial Engineer.* A few months later the name was shortened to INDUSTRIAL ENGINEER.

D. H. Braymer became Editorial Director in 1922 and was succeeded in 1925 by G. A. Van Brunt, the present Editor.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

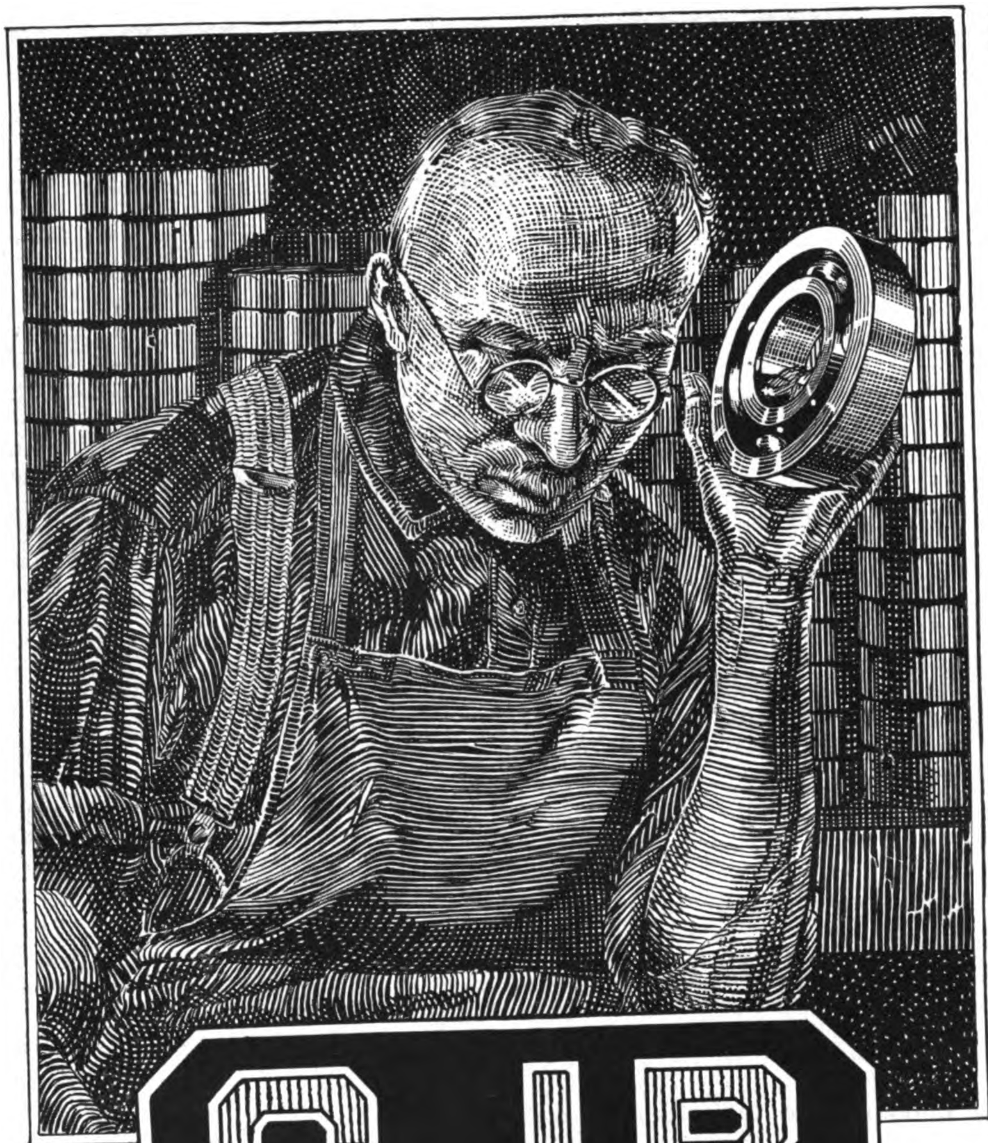
WASHINGTON, Colorado Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Star Building
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4

Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record — American Machinist
Power — Chemical and Metallurgical Engineering
Coal Age — Engineering and Mining Journal
Ingeniería Internacional — Successful Methods
Bus Transportation — Electric Railway Journal
Electrical World — Electrical Merchandising
Industrial Engineer — Radio Retailing
Electrical West
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Parguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.



INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 85 New York, January, 1927 *Number 1*

Details and Objectives That May Be Overlooked When

Planning an Installation of Electrical Equipment

By MARIN PHILLIPS
Assistant Electrical Superintendent, International Paper Company, Niagara Falls, N. Y.

IN A modern industrial plant the total cost of the electrical equipment represents a fairly large percentage of the total cost of the project, and yet it is, unfortunately, sometimes treated as a minor item in the planning of the installation as a whole. Furthermore, although many of the engineering problems are given the consideration they merit, it is not uncommon to find that many important details have been overlooked, with the result that a great deal of unnecessary trouble and expense are caused later on. Trouble-free installations of electrical equipment are not the result of chance; nor can continuity of operation and low operating costs be expected when the installation has been planned and the equipment installed in a haphazard manner.

I am a firm believer in a good, clean-cut electrical installation, and in this article I will discuss briefly some of the points that I have found by experience are likely to be overlooked.

In planning any installation, the following objectives and considerations should be kept firmly in mind:

(1) To make the installation as safe and as accessible as possible for the operators and maintenance men.

(2) Expense should be kept down as much as possible, *without endangering a good, safe layout.*

(3) The most economical centers of distribution should be selected, considering the location of the equipment and the driven machinery.

(4) Number of main feeders that should be run.

(5) Over-capacity to be allotted to the main feeders, which will be based partly on the number of motors that will be tapped off in the future.

(6) How much of the wiring should be run in conduit?

PLANNING the layout of an electrical system for an industrial plant requires vision and foresight, as well as sound engineering knowledge. When a definite problem is presented, in which all factors are known, finding the solution is in many cases largely a matter of applying well-known formulas. However, good judgment alone, based on experience, must be relied upon to solve some of the problems on whose correct solution a good deal depends in the way of economy of installation and operating efficiency. In this article Mr. Phillips discusses some of the objectives and details that are likely to be overlooked when plans for an electrical installation are being made.

(7) Purchase equipment that has been proven by practical experience to be the most reliable and require the least amount of maintenance to keep it in first-class condition.

(8) Endeavor to see that the equipment is so located that it will not be in the way of other machinery and yet be accessible for operation and repairs.

Taking these points up in order, (1) to make the installation as safe electrically as possible for the operators and repairmen, there must be a minimum of exposed, live parts. Furthermore, to make it safe for the maintenance men, while changing fuses and making repairs, it must be as accessible as possible, so that it will not be necessary for them to climb ladders, or work in close, dangerous places. Fifty per cent of the burns and other accidents to electrical workers can be traced to the poor conditions under which they are working. With industrial plants striving as hard as they are to cut down the number of accidents that occur each year, proper installation of the electrical equipment, which makes for safer working conditions, is an important factor in making this huge drive a success.

(2) *Keeping Expense Down*—If first cost only is being considered when planning and laying out an electrical installation, the one that is least expensive at first is more than likely to be the most expensive in the long run, due to equipment failures with their resultant produc-

tion delays and high maintenance cost.

Failures in Junction Boxes

For example, when expense is the only point considered in laying out a new electrical installation, the main power feeders are most frequently run through the building high up on the wall or ceiling, junction boxes being located where it is decided to tap off for motor circuits. Another cutout box with fuses is mounted alongside it, with a line run from there to the motor starting equipment. This arrangement is open to a number of objections. First, it is very difficult to make a good splice in a junction box and solder it without damaging the insulation, unless the box is made unnecessarily large. I have seen a great many grounds and burnouts occur in junction boxes that were part of a new installation that had been in service only a short time, as well as in old installations.

These failures in junction boxes usually damage the wiring back into the conduit, so that the splice will have to be taken apart and a length of conduit removed on both sides in order to make a temporary splice in the wiring. In the meantime production is held up on whatever machines are depending on the faulty line for power. Any money spent in eliminating as many weak links in the power system as possible is money spent to good advantage and is sure to pay a good dividend in the long run.

Considering details for a moment, when making splices in light and power wiring, the workman usually uses a blowtorch for soldering the joints, which are heated by playing the flame directly onto them. This heats the wire for a considerable distance back in the conduit and is likely to damage the insulation if extreme care is not taken to avoid it. Very often failures in wiring can be traced directly to this cause. It is almost always necessary to have splices in junction boxes and the methods of doing this shown in Fig. 1, which I have used for several years, have been found to be very satisfactory and dependable in every way.

A splice made by soldering on lugs and bolting them together is shown at *A*. Lockwashers are placed under the nuts to keep them from working loose. Diagram *B* shows how to make the splice by twisting the wires together in what is known as a pigtail splice, which is most suitable for small power and light wiring. To solder the splice, a pot of molten solder is raised up until the wires dip into it, and then lowered. Most likely a thick coat of solder will stick to the splice, which will indicate that the joint is not hot enough. The pot is raised and lowered until the solder runs off freely, leaving a very fine coat, with no lumps or drops hanging from the wire.

The method shown in *A* has some advantages that *B* does not possess. For example, the splice is easily made without any danger of damaging the insulation, and it is very convenient in case a section of the conduit has to be moved to make room for new machinery or during alterations, as the connections can be unbolted so that it is not necessary to untwist the wires. This method of making a splice is also a great aid when trouble develops, as it can quickly be located by unbolting the splices so as to break the circuit up into sections and thus permit each section to be tested separately. When the trouble is located and repaired, the splices that were taken apart can be quickly rejoined.

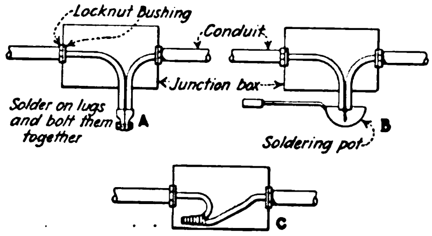


Fig. 1—With these two methods of making splices in junction boxes, there is little danger of overheating the insulation.

In *A*, lugs have been soldered on the ends of the wires, and then bolted together. With this arrangement it is easy to sectionalize or open up feeder circuits. When the conductors are not too large, a pigtail splice may be made and the joint soldered by dipping it in molten solder, as shown in *B*. After the splices have been made, by either method, they are taped and the conductors bent back into the box, as in *C*.

When a blowtorch is played on a splice it takes a considerable length of time for the wire to get hot enough to melt the solder. While the wire is heating up slowly, the heat follows the wire back under the insulation. Nine chances to one, the rubber insulation is well baked back into the conduit, and after the splice has cooled any attempt to move it will crack the insulation.

When making a splice as shown in either *A* or *B* of Fig. 1, it is made near one end of the junction box and then after taping the splice well, it is bent back into the junction box so that the cover can be closed. Only one wire is shown spliced in the illustration, so as to indicate the method more clearly.

Feeder Lines

Another objection to running only one or two long feeder lines and splicing in at a junction box wherever a motor is to be located is that the motors driving different machines will be on the same feeder line and if trouble develops on the feeder, or the main circuit breaker trips out for any reason, it may shut down several machines, instead of one. Any trouble that develops in an electrical system is bad enough without having it multiply by spreading to several machines and the time spent in planning a system such that minor troubles can not spread very far into it is well spent.

It is fairly common practice to run one main feeder to several panel boxes built up out of busbars, knife switches and fuses; sometimes no switches are used—only fuse block cutouts. This method also has some disadvantages, among the most important of which is that if anything goes wrong with one of these panel boxes it may hold up production in the entire plant. Also, there are so many live parts exposed when the cover is opened that it is dangerous to the operators and maintenance men. Again, it is easy to cause a short-circuit, or pull the wrong fuse, when changing a blown one. About the only advantage that such panel boxes have is that they take up only a small space.

The panel box shown in Fig. 2 was built up of enclosed safety switches for the purpose of overcoming these objectionable disadvantages, and has measured up to all that was expected of it, by reducing accidents and delays and speeding up the clearing of any troubles that do occur.

As will be seen, it is built in two separate sections, one part comprising the frame for mounting the switches on, the other being an enclosure or distribution box for the busbars from which power is distributed from the main feeder to the group of safety switches. That part of the box on which the switches are mounted is built out of T or angle iron and mounted on a piece of channel iron. On the upright framework is mounted a sheet of No. 14 gage

iron; the safety switches are mounted on this. The dimensions of such a panel box will depend entirely on the size and number of switches required. Fig. 2 shows the correct dimensions for a box mounting nine 60-amp., 500-volt safety switches.

The distribution box shown mounted on top of the panel box framework is constructed of No. 14 gage sheet iron and contains the busbars which are mounted in it on slate bases that have slots sawed in them to hold the busbars in place, so that they cannot move around or cause a short-circuit. The busbars are made long enough to come within about 6 in. of each end of the distribution box.

The main power line feeder is run in conduit from the switchboard to the distribution box and terminal lugs are soldered onto the wires and then bolted to the busbars. Short lengths of conduit (short nipples are used for switches on the top row) run from the top of each safety switch into the bottom of the distribution box. These conduits contain the wiring for the switches, which is tapped onto the top terminals of the switches and onto the busbars through terminal lugs which are soldered onto the wires and fastened with brass machine screws, holes for which are drilled and tapped in the busbars.

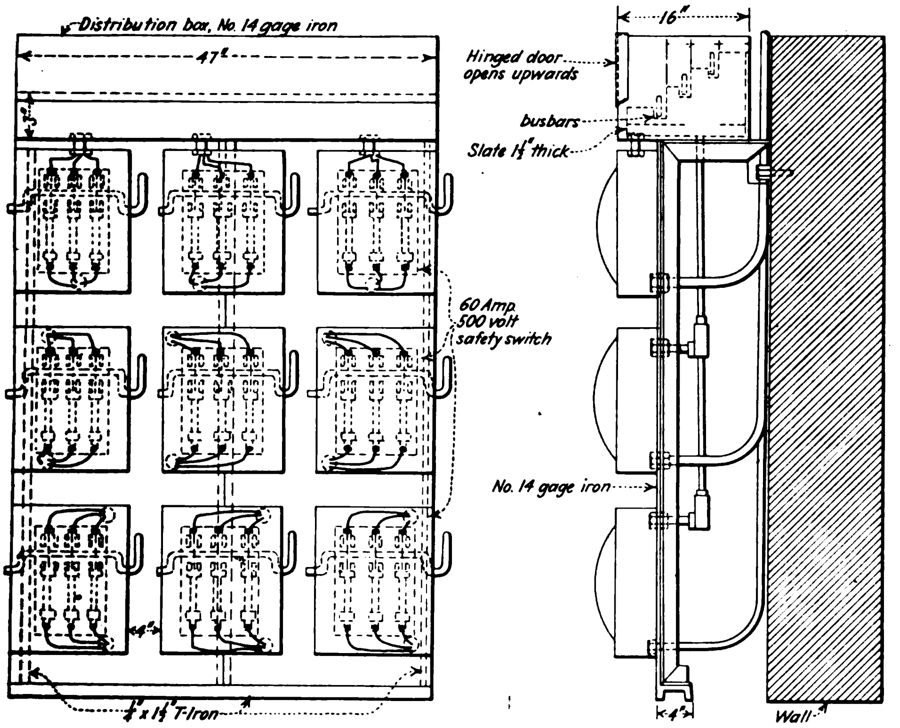
By connecting the top terminals of the safety switches onto the busbars the fuses can be made dead by pulling the switches, and can then be changed without any danger of coming in contact with live parts, which is a good safety measure in protecting the operators or maintenance men who will be called upon to change them. To provide for the possibility of someone not pulling the switch before opening the door to change the fuses, the switches should be so constructed that they cannot be opened until the switch has been pulled. They should be provided with a key so that they can be opened for tests and inspection whenever it is desired to do so without opening the switch.

The distribution box containing the live busbars is mounted with the front side and door on a line with the front side of the switches, as shown in the side view in Fig. 2. It is necessary to leave only enough room between the top of the upper row of safety switches and the bottom of the distribution box to allow the covers of the switches to be opened and closed, which will usually be less than 1 in., depending on the size and type of switch.

When building up the panel box, it is advisable in most cases to make it a little larger than is needed at present, if it is thought that it will be necessary to take care of future installations of motors. For example, leave enough space on the bottom or sides to mount another row of switches when needed.

Such a type of panel box has a good many advantages to its credit. First, it provides independent circuits for the motors, which can be isolated into groups for different machines. Second, it is accessible, which makes it safe, allowing fuses to be changed without danger, and repairs to be easily made. Third, there are no splices, such as are made in junction boxes, which insures a better installation, resulting in less service delays and interruptions. Fourth, this panel box guards against the dangers of a short-circuit, as all circuits are well separated, and there is no danger of coming in contact with the main live busbars when working on the switches and changing fuses. Fifth, new sections can be added onto the sides of the panel box as they are needed, and the switches can be changed to a larger size if necessary when changing to a larger motor.

Fig. 2—Here is a panel box that combines safety with accessibility.
The safety switches are mounted on a sheet of No. 14 gage iron which is fastened to a framework of 14-in. x 1¼-in. T iron. The busbars from which power is distributed to the safety switches are enclosed in a sheet-iron box placed above the switch rack and mounted, as shown, on slate bases screwed to the bottom of the box by $\frac{3}{16}$-in. capscrews driven into Ackerman Johnson expanding screw anchors.



Switch and Control Units

Fig. 3 shows a good method of installing starting boxes and switches as a single unit, in places where it is not necessary to build up a panel box. The framework is built out of ¼-in. x 1½-in. angle iron. A framework of this kind makes a good, substantial installation and has the advantage of making it easy to change a switch or starter. Another good point is that the starter and switches can be mounted as a unit in the shop and set up very easily when wanted. Also, in case of failure of a starter or switch, or the installation of a larger-sized motor to meet an emergency, a spare unit can be quickly set up.

Sometimes it will be found of advantage to mount a number of motor starters and switches on one panel when it is desired to control several motors from one point. In this case a panel similar to the one shown in Fig. 2, with the distribution box mounted on top of the starter rack, may be made up. The framework should be constructed of angle iron, the size depending on the size and number of starters required. An installation of this kind looks neat, and will speed up inspection and the changing of contacts.

I once had occasion to put in a new installation of starters and motors in a plant in which part of the power was generated and the rest purchased. As much load as possible

was carried on the generating system, and the rest thrown onto purchased power. The load was regulated by double-throw switches. Fig. 4 shows how the switches and starters were mounted on a starter rack, as it was desired to control several motors from one point. The double buses are shown mounted on top of the starter rack with one bus above the other, and separated by two insulators, in order to keep the rack as near the wall as possible. As it was desired to fuse both lines ahead of the starter, double-throw, non-fused safety switches were used, and the fuses were mounted in a cabinet below the switch. This arrangement saved one set of fuses, and had the additional advantage that the fuses could be killed by opening the switch. By building this type of a distribution panel considerable conduit, wiring and labor was saved by not having to run two sources of power lines to widely scattered motor starters.

(3) *Distribution Centers*—Selecting the most economical centers of distribution requires considerable study and forethought in order to plan and lay them out correctly, keeping the following points in mind: Will future installations of machines make it necessary to move them later on? Is it cheaper to run the main feeders up close to where the motors are to be set, and run short lines to them, or stop the main feeders farther away and have longer small lines running to each motor? This can be answered satisfactorily only by figuring the cost of the conduit, wire, labor, etc., for the small lines and comparing it with the cost of the large line.

(4) *Number of Feeders*—A decision as to the number of main feeder lines to run will depend mostly on the size of the contemplated installation, and how it is planned to group the machines. If it is decided that the motors for each machine are to be kept independent from the rest, one main feeder line should be run to take care of the individual motors for each machine. This applies, of course, only to machines having several motors. It will usually be satisfactory to run a main feeder line to take care of several machines.

(5) *Excess Capacity*—The amount of over-capacity to allot to each feeder line will depend on whether there is likely to be any future installations of machinery that will have more or larger motors to be tapped off the feeder, or whether motors will be changed to larger sizes later on. In my experience I have found that it pays to install a main feeder with 25 to 50 per cent over-capacity to take care of future installations of motors. When the center of distribution has been finally selected and the total horsepower load of the motors to be tapped off has been determined, the size of the main feeder line can then be decided on.

(6) *Use of Conduit*—The question of whether to put all wiring in conduit is a big one. From the standpoint of reliability, all small wiring should be run in conduit, for this makes a good, safe layout and when properly installed it will require very little maintenance expense. Also, there is not much danger of shutdowns due to the wiring being damaged. But when large main feeder lines, above 500,000 cir.mil size, are involved, they can in most cases be run as open wiring well up out of the way, and this arrangement will prove to be just as reliable if not more so than the use of conduit, in which case the heavy wires have to be forced into conduit fittings and junction boxes.

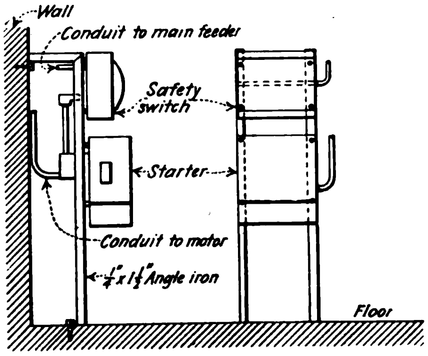


Fig. 3—Mounting starters and switches as a unit facilitates installation and replacements.

(7) *Location of Equipment*—Placing equipment so that it will not be in the way of the other machinery is of vital importance. Besides the expense there is nothing that is any more disheartening than to have a nice installation of starting boxes, switches, panel boxes and so on all set up and ready to run, and then find, when you start to congratulate yourself on being ahead of the machinery erectors, that one of your prize installations has to be torn down and moved to make room for some other machinery. Of course, it is not always the fault of the man in charge of the electrical construction when some work has to be moved, as very often the original plans have been changed for various reasons. But any effort put forth in avoiding such happenings is certainly worth while. The man in charge of the electrical construction should have blueprints of all layouts of the piping, machines, sprinkler system, and the like, and study them well before locating the electrical equipment.

(8) *Selection of Equipment*—The question of purchasing equipment that will give the best service and require the least amount of maintenance work when installed is a big one, and requires careful study.

In many cases a list of needed equipment is submitted to the different manufacturers for bids, without a plain statement of the specifications that must be met as to quality of materials, or the exact conditions under which the equipment will have to operate. Again, unless care is taken, there is a tendency to award the order to the manufacturer who has submitted the lowest bid, without any consideration of the quality of the equipment, the cost of upkeep after it is installed, or whether it fully meets the specifications and requirements.

True enough, the first cost of a new installation is dreaded, for it means spending hard-earned money, but that money is spent for the purpose of making more with it and when the installation is completed the only way to do this is to keep the wheels turning day in and day out. The cost of maintenance is certainly worth careful consideration.

There is, after all, comparatively little difference between the cost of a good installation and that of a so-called cheap installation that will prove to be unreliable when installed: certainly not enough to be the deciding factor. The cost of maintenance and repairs may be only a small amount, compared with the time lost in production by the machines when they are shut down while repairs are being made to the equipment that drives them.

As a general rule motors, when properly applied and installed, and given a reasonable amount of attention, will operate very satisfactorily and give very little trouble. The starting equipment and switches controlling the motors are the most important items to take into consideration and should be selected with great care, keeping the following points in mind: How long will it take to change the contacts? Will all of the contacts be made accessible for changing by removing the cover, or will part of them be hidden away

behind coils, and the like, so that the starter will have to be disconnected and taken apart to get at them? Will the parts be interchangeable for three or four different horsepower ratings, so as to reduce the number of spare parts to a minimum?

It is not uncommon for a small controller or switch to be part of the drive for an important machine that is producing from $100 to $200 worth of finished products per hour. With this fact in mind, it can readily be seen that every minute is precious and counts while the controller is out of service for repairs.

A piece of starting equipment that has all contacts in plain view and easy to get at when the cover is removed may cost $100, while another one of the same capacity but having a part of its contacts in an inaccessible place may cost only $85. It is very evident that the latter type is going to take more time in locating troubles and making repairs and adjustments, and the extra maintenance cost will soon amount to more than the difference in cost between the two starters, to say nothing about the time lost in production.

Standardization of Equipment

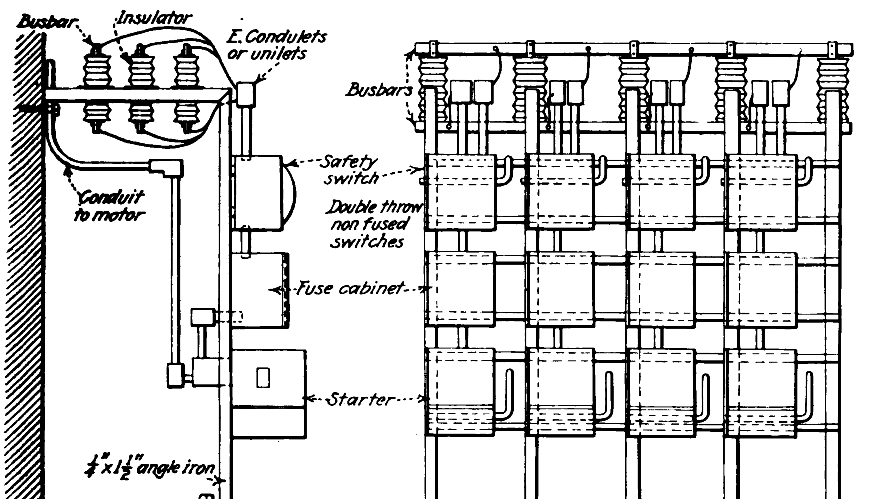
There is a strong tendency today to standardize equipment, which is a fine thing as far as it goes. The main advantage is that we will have to keep fewer spares and less repair parts in stock for emergencies. Can we standardize completely on equipment and keep up with the steady march of progress? Any answer to this question must be qualified. We can standardize on one particular manufacturer's equipment, refusing to consider all other makes, whether good or bad, and fool ourselves into thinking that we will be carrying less spares and repair parts. It has been my experience, however, that anyone who standardized on one particular line of electrical equipment ten years ago, and has bought nothing else since, now has a pretty good collection of repair parts, due to the manufacturer whose equipment he has standardized on, changing the type and construction of his equipment three or four times in trying to make improvements. In some cases the equipment has been improved, and in others a backward step may have been taken. I have had four 5-hp., 900-r.p.m. motors of the same make in my care, each of which used a different size and type of bearing. Can we standardize on equipment like this and keep the stock of repair parts low? Should we turn another salesman away, who has another motor or whatnot which may be as good or better than we are using, with the sole remark that we have standardized on a particular manufacturer's line of equipment, when the spare parts on hand may not fit the next item you purchase from him?

Standardization is desirable if it can be carried out to advantage. We all want the best equipment that we can possibly get, and the only way to know which is best is to try out the new lines of equipment as they are developed. I do not mean by this that we should buy every new piece of equipment that is put on the market. However, if a new type of switch or controller is developed, it will pay to look it over. If it appears to be a good design and we cannot find any reason why we do not want it, except that we have already standardized on another line, it will be well to purchase one of them, install it and give it a fair trial in service. If it proves to be any better than the ones already in use, then the next large new installation of equipment should be of this type.

I know of one particular new installation for which a large number of new switches were purchased on the basis of the bids received, and proved to be a failure in every way, by not standing up on the operating voltage and being very awkward to work on. This was a sad and costly experience that could have been avoided by a better knowledge of equipment, gained by trying out the new designs as they were developed.

Fig. 4—Method of installing two sets of busbars on separate sources of supply with safety switches, fuse cabinets, and starters.

One set of buses is fed from the plant generating system, while the other distributes purchased energy. It was desired to control a number of motors from one point and in order to facilitate adjustment of the load so that the plant generator can be kept fully loaded, double-throw switches were used, which makes it possible to operate any desired number of motors on generated or purchased energy.



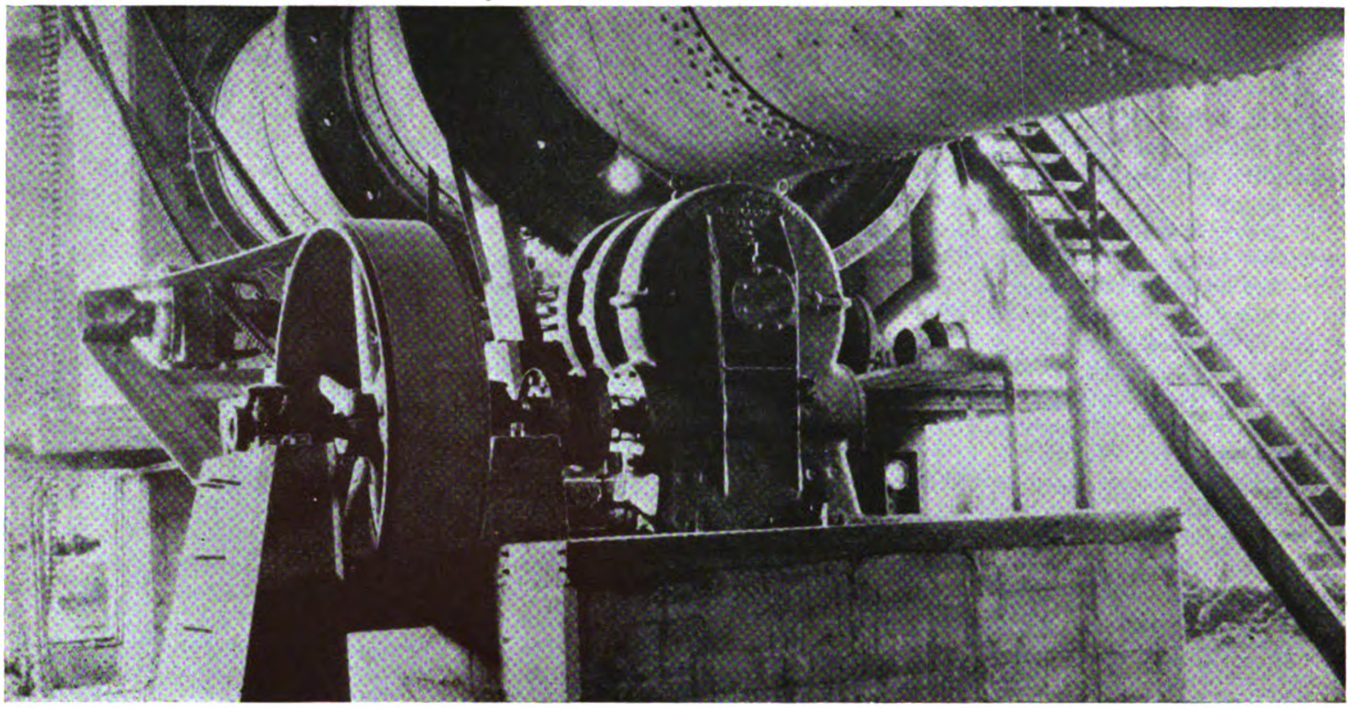
Testing New Installation

After an installation is completed and the motors are in operation they should be tested with a wattmeter, preferably of the curve-drawing type, so that the test records can be preserved for future use. In most cases many of the motors will be found to be operating overloaded, while some will be underloaded. They should then be changed and rearranged, so that they will be operating as nearly fully loaded as possible. This will improve the power factor, which will increase the efficiency and improve operating conditions, by insuring better voltage regulation. It will also decrease the load on the generators.

Testing of the motors can be done much more cheaply and quickly if several of the safety switches are mounted together on a common panel box, so that it is not necessary to move the current and potential transformers and other testing equipment to a new location every time a motor is tested.

Test sockets can be obtained from the switch manufacturers for use on all switches controlling important drives that cannot be shut down to cut in the meter. Current transformers of the split-core type will also be found very useful and handy.

When the installation is completed, the name of the drive that each switch controls should be stenciled on the cover, to prevent mistakes when pulling the switches.



An example of a compact installation of a worm drive, connected to a rock dryer in a cement plant.

Any drive equipment in service like this is subjected to a shifting and impact load due to the rolling of the contents of the dryer. Notice the outboard bearing to take the radial load of the belt on the worm bearing.

Use of Worm Reduction Units for Power Transmission

UNTIL within recent years technical schools have taught, and many engineers and designers have believed, that worm gearing was a rather inefficient means of transmitting power, but that for providing a high ratio of reduction in a compact mechanism its use was sometimes advisable. This teaching was based on the sad experience of many users of worm gearing because such gearing as was available at that time was hopelessly inefficient and generally unsatisfactory. As a result, most engineering handbooks, as well as the literature published by many gear manufacturers, treated worm gearing as a mechanism that could be operated, at best inefficiently, only at slow speeds and could not be used to transmit heavy continuous loads. Unfortunately many of the texts and reference books for engineers and operating men have not been brought up to date on the use of worms for speed reduction and power transmission.

By G. H. ACKER

Chief Engineer, The Cleveland Worm and Gear Co., Cleveland, Ohio

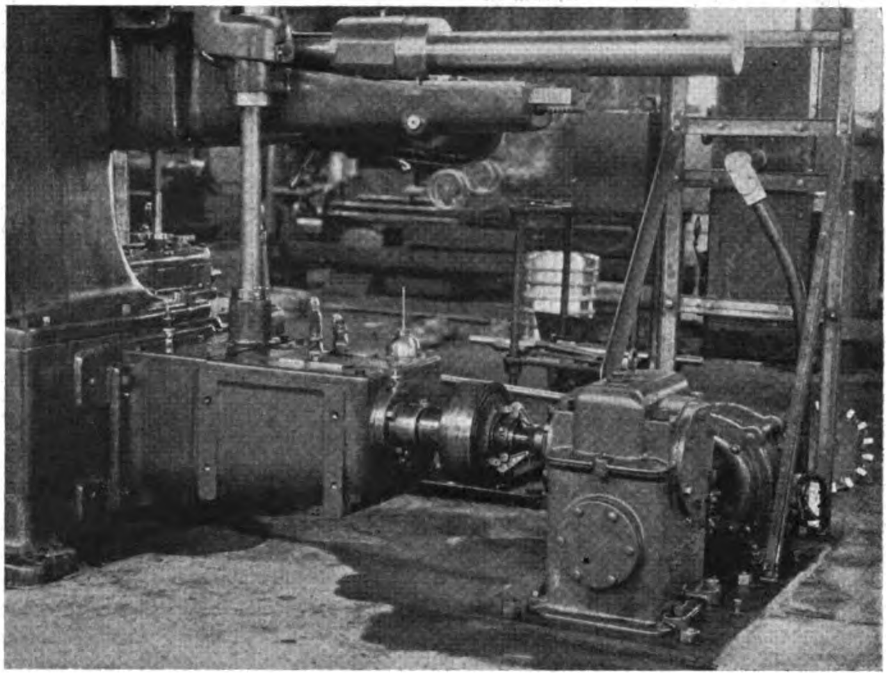
At present, however, worm gearing is emerging from the shadows of its former reputation and is taking its place as a real factor in the solution of power transmission problems. The change is largely due to the development of the worm gear as a result of its use in motor trucks for rear axle drives.

The worm gear of today is similar to the old style worm gearing in that it consists of a worm meshing with a gear, but at this point the similarity ceases. In performance the two types are utterly different; the superiority of the gear of today is due to the improvements in tooth and thread design, in addition to the use of proper materials and workmanship. The old cast-iron worm and gear with cast teeth would, obviously, be impractical and impossible for high-speed operation.

Some remarkable performances of worm-gear speed reduction units are on record. In one installation, for instance, an induced draft fan was driven through a worm-gear reduction unit by means of a 100-hp., 3,200-r.p.m. steam turbine. The reduction ratio in the unit was 10¾ to 1. The drive was installed in 1920 and ran continuously for nearly 4 yr., when a rearrangement of the plant necessitated a shutdown.

It is immediately apparent that here is something quite different from the old type of worm gearing. First, in this installation the worm speed was about four times what was formerly thought to be safe. Second, the power transmitted was reasonably high for a single set of gearing. Third, the drive was in continuous operation. Fourth, the unit showed an actual efficiency under test of 94 per cent.

A feature of the modern worm gear reduction unit that is especially important is its ability to maintain



Here the worm reduction unit is direct-connected to a boring mill through a clutch.

The angle-iron framework for supporting the starting equipment is built over the motor not only for protection, but also to economize on floor space. The right-angle drive also saves floor space.

its high efficiency throughout its life. On some units the worm threads are hardened and ground and the mating gear is made of high-grade phosphorized bronze. Any wear must, therefore, occur on the gear teeth and, since these teeth are cut by the hobbing method, the action of the worm threads on the teeth is exactly the same as the hob that generated the original tooth contour. It follows, therefore, that even after considerable wear has occurred, and this should be retarded by adequate lubrication, the meshing surfaces bear exactly the same relation as at first. This accounts for the maintained efficiency and is, moreover, a feature not found in any other form of gearing.

The amount of wear that occurs in a speed reduction unit is also important. For example, the record of a mechanical gas producer with a worm-gear drive, which is shown in an accompanying illustration, is interesting. In commenting on the performance of this drive the builder of the machine made the following statement: "The first producer with the worm-gear drive was put into service in August, 1922. A year and a half later it was taken down, examined and checked carefully. There was absolutely no indication of any kind of wear on the worms or gears. It had been running 24 hr. per day and seven days a week, a service which was the equivalent of about 5 yr. of ordinary 8 hr. per day operation. We feel confident that the worm gear drive will give ten years' service under these extreme conditions without any repairs."

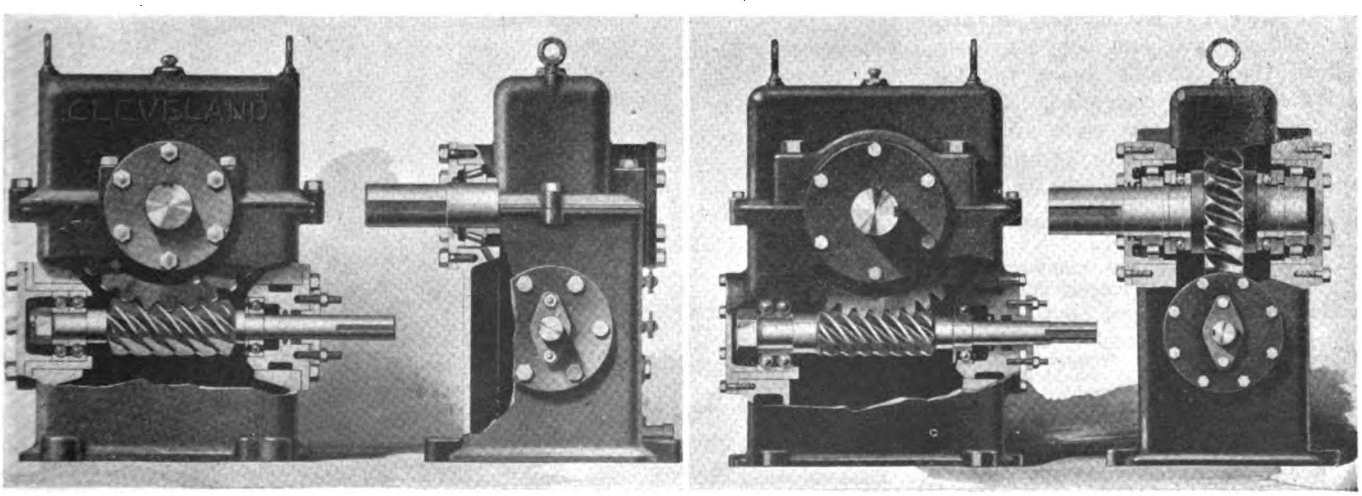
This producer drive is of the double-reduction design, in which two worms and two gears are incorporated. The total reduction between the motor and the bevel pinion is 528 to 1 and the poker and ash dump are driven from a crank attached to the first gear shaft. The compactness and neatness of the drive will be noted from the illustration.

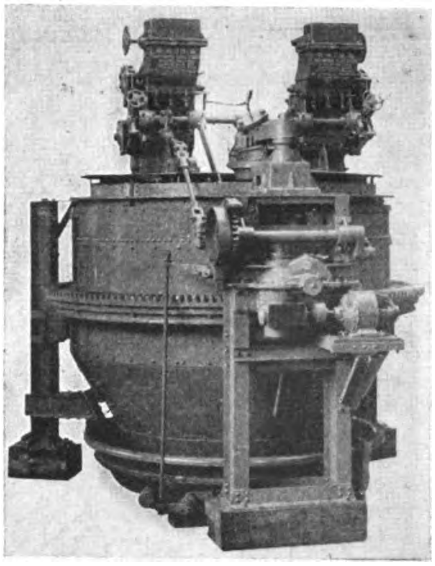
One of the first applications of the automotive type of worm gearing to an industrial drive was in connection with a mechanism for operating open-hearth furnace doors in a large steel plant. The special drive built for this purpose is shown on page 8. A total of 50 units of this same type were installed in 1917. The service is intermittent and not particularly severe, but the satisfactory results have led to the application of worm gearing to a great variety of other drives in the leading steel plants. Since these drives were installed the design of the units has been much improved.

So far as severity of service is concerned, the drive illustrated at the beginning of this article offers quite a contrast to the preceding installation. The reduction unit in this case

Bearing construction of two types of worm reducers.

The worm shaft in both units is supported on a double-row ball bearing at the back and a single row of balls at the front. In each of these cases the provision for preventing oil working out around the worm shaft is slightly different, as may be seen from the illustrations. The gear bearing in the unit at the left is designed for a torque load and is supported on tapered roller bearings. The worm shaft in the unit at the right is designed to carry not only the torque, but also a radial load due to a belt and pulley or a gear and pinion drive, which gives torque as well as a side pull. In this case the shaft is supported on roller bearings and ball thrust bearings. Many users of reducers fail to differentiate between the torque and radial or side load and its effect upon the bearings.





This double-reduction worm unit serves a dual purpose.

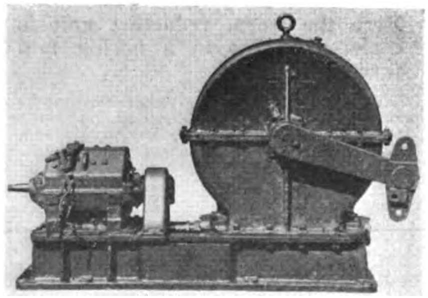
Where an extremely large reduction is desirable, or where different parts of the equipment operate at different speeds, double-reduction units are frequently used where one speed is taken off at the first reduction and another lower speed is taken off at the second reduction as in this case.

is connected in the drive of a large rock dryer in a cement mill. The dryer is 8 ft. in diameter by 80 ft. long and rather dwarfs the reduction unit, although the over-all height of the unit is nearly 6 ft. In addition to the fact that the horsepower transmitted is high and the operation continuous, the gearing is subjected to severe impacts and shocks due to the characteristics of the load. Other applications of worm gear reduction units to kiln, dryer and cooler service have been made with the motor direct-connected to the worm shaft and have proved equally satisfactory. The unit illustrated is transmitting 85 hp. with an 8.4 to 1 reduction ratio.

For conveyor and elevator drives the outstanding advantage of the worm gear reduction unit is its compactness. As it can be installed in a small space it is particularly adapted for use on coal and ash conveyors where the available space for the drive is usually restricted. The relation of the shafts on a single-reduction worm reducer is such that the input and output shafts are at right angles to each other. For this reason the worm and its drive can be installed alongside and parallel to a conveyor, which is more economical of space than if the drive had to be installed at a right angle to the line of the conveyor and extend out into the aisle. The gear shaft of the standard worm unit can be extended either to the right or to the left of the housing, or on both sides. The worm is so mounted that it can be rotated in either direction.

The use of high-grade, anti-friction bearings on the two shafts of industrial worm-gear speed reduction units has been an important factor in their successful performance. A standard drive, in which the worm shaft is mounted on ball bearings and the gear shaft on tapered roller bearings, is shown in the accompanying illustration at the left at the bottom of page 7 and represents a high development in the modern worm gear reduction unit.

The use of anti-friction bearings, for both shafts, not only increases the over-all efficiency of the drive, but also adds to the durability of the mechanism. Worm gearing, in order to maintain its efficiency over a long period, must be held accurately in alignment. For long life and reliable, efficient operation, the prevention of bearing wear is more necessary than the prevention of gear wear. The amount of bearing wear which might be tolerated with other types of gearing is likely to cause serious deterioration in a worm gear drive. The use of anti-friction bearings, however, obviates this difficulty entirely, and provides the additional advantages of easy and accurate replacement in case of unavoidable accidents or breakdowns.



This is a different type of double-reduction unit.

The motor is connected through a gear drive to the worm shaft for the first reduction. The second or worm reduction is connected to an open hearth furnace door opener.

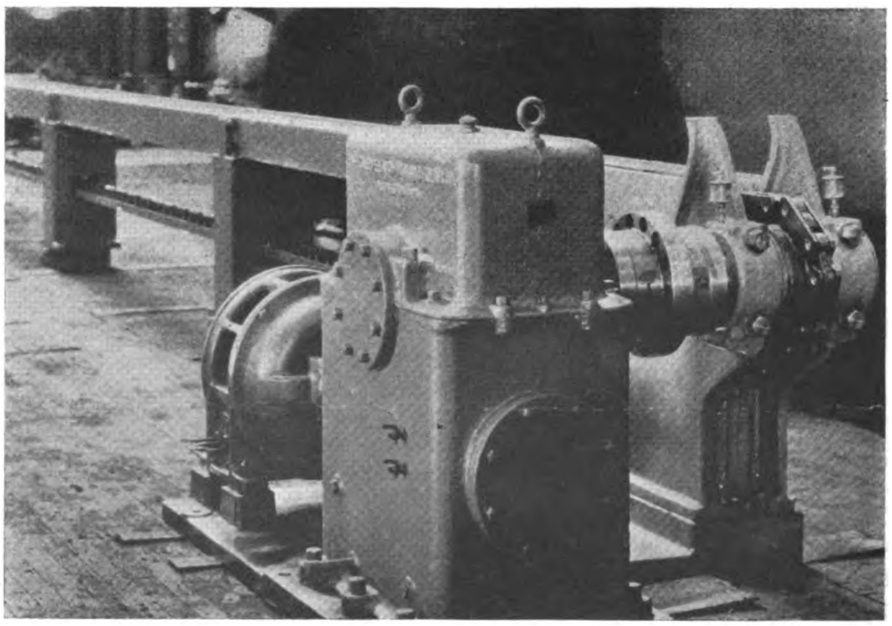
Many users of speed reduction units do not realize the importance of the two types of loads which may be applied to the shafts and bearings. The first is a torque load such as is applied by a motor driving in a straight line through a flexible coupling. The more severe service comes from an overhung load such as results from a belt or gear on the shaft, which gives not only the torque but also a side pull or radial load. It is this side load which is likely to cause trouble and is frequently not given sufficient consideration by the user.

Even in the case of a reduction unit designed to carry an overhung load on the gear shaft, the use of anti-friction bearings has been found distinctly advantageous. A reduction unit designed for this type of service is shown in the illustration at the right at the bottom of page 7. The gear shaft of this unit is

(Please turn to page 11)

An example of the compact arrangement of a worm speed-reducer drive.

Because a worm gives a right-angle drive, the motor can frequently be installed alongside the machine which it drives and so economize on floor space. Here the worm is connected to a wire-drawing bench through a Francke flexible coupling. The worm reducer gives a 22½ to 1 reduction from a 720-r.p.m., 25-hp. motor.



JAMES B. HOLSTON *answers the question*

"How High Should I Raise Our Power Factor?"

PREVIOUS ARTICLES of this series have appeared in the July, August and September issues. In these articles power factor was discussed from the standpoints of the cause and nature of this condition, its effects in creating undesirable operating conditions and increasing the cost of the electrical energy consumed, and the practical methods of correcting it, both with and without the use of special equipment designed for this purpose. In this article Mr. Holston shows the considerations involved in determining how high the power factor of an industrial plant can profitably be raised.

WHEN making a study of an industrial plant installation, the first step is to determine whether or not power factor correction will be profitable; then the most economical method of correcting power factor must be selected. The final consideration is how far it will pay to go in the correction program. That phase of the problem will be discussed in this article.

As with most problems of an engineering nature, all of the factors and conditions that have a bearing on the problem require careful consideration, as the correct solution will be found only when proper disposal has been made of the particular difficulties that arise in every case.

The first step in the power factor correction program is to determine whether or not existing equipment can be operated at a better power factor. Any results in the way of raising power factor that may be obtained by rearrangement of the driven machines, or motors, will usually more than pay for the cost of making the changes. However, it is seldom possible to raise the power factor of an installation above 80 per cent without using one or more of the various types of corrective equipment designed for this purpose. In the article in the September issue these types were listed as follows:

(1) Synchronous motors.
(2) Fynn-Weichsel motors.
(3) Static condensers.
(4) Synchronous condensers.

Although all four types have their particular applications, it is probable that in the majority of cases one or the other of the first two types of equipment offers the most satisfactory means of obtaining the correction needed. Occasionally, however, it is found that corrective motors will not raise the power factor quite high enough, and the added expense of condensers to be used in addition to the motors may be justified. In cases of this kind it must be remembered that the added investment is justified only when the *increased* saving made possible thereby warrants it. In other words, the total saving due to power factor correction should not be used to justify the total investment in corrective equipment; only the additional saving made possible by the use of extra correction equipment can be used as justification for the extra expenditure involved.

What High Power Factor Does

In order to make clear what follows, it may be well to answer again the question, What are the benefits of power factor correction? Briefly, they are: better voltage regulation; lower line losses; discounts on power bills. Specifically, better voltage regulation throughout the plant means more efficient operation of all motors as well as better speed characteristics; it also means better lighting conditions. Lower line losses mean less power consumption, which, with the power factor discount, gives a direct reduction in the power bill.

The saving in line losses depends upon the type of corrective equipment installed. Reference to the line diagram in Fig. 1 will help to make the following discussion clearer. Power factor correction by the power company usually is made on their own portion of the distribution system, section *A*, which means that no benefit accrues to the consumers except better voltage regulation on the main feeder. Power factor by the consumer can, on the other hand, be made in one or more of four places: on the primary, or high-voltage side of the transformer bank; on the secondary, or low-voltage side; at the distribution centers; or on the individual circuits. Obviously the greatest benefits are derived from correction on the individual circuits, since the lower current flowing, by reason of the high power factor, results in a reduction of line losses throughout the system. Frequently, a single unit of corrective apparatus at each local distribution center will afford the most satisfactory means of power factor correction. Unity power factor from the local centers back to the meters is a very satisfactory condition.

Some idea of the relative magnitude of system losses and the savings resulting from power factor correction may be gained from a consideration of the laws governing line currents, losses, and power factor.

In the first place, system losses vary directly as the current squared; current, in turn, is inversely proportional to the power factor; therefore, the losses vary inversely as power factor squared. In a system designed to operate with 5 per cent line loss at 85 per cent power factor, the loss at 60 per cent power factor is found as follows:

$.05 \times (85)^2 \div (60)^2 = 10.03$ per cent

Furthermore, the loss at 100 per cent power factor is:

$.05 \times (85)^2 \div (100)^2 = 3.61$ per cent

In any system, raising the power factor from 60 per cent to 100 per cent will pay a return of 10.00 per cent minus 3.61, or 6.42 per cent of the total energy consumed. If a plant uses 100,000 kw.-hr. per month at a cost of 2 cents per kw.-hr., and the power factor is raised through-

out the system from 60 per cent to 100 per cent, the saving will be 100,000 × 6.42 per cent × 0.02, or $128.40 each month. This amounts to $1,540.80 in a year. Capitalized at 15 per cent this saving represents an investment of over $10,000.

Of course, it must be noted that correction throughout the system is necessary before such savings are possible. A quantitative determination of the savings resulting from correction, when made at the several possible points of the system, is a laborious process involving, as it does, wire sizes, line drops, currents, load factors, and other variables. The value of the results of such calculations, in view of the work required, is doubtful. It is sufficient to say that if the choice lies between two or more of the several places where correction may be applied, the one farthest in the system should be chosen.

Limits of Correction

Having given due regard to the expediency of the various methods and the location of the apparatus used, we come to the final question of just how far to go with the correction program. The problem resolves itself into a simple one of return per dollar of investment.

As an example, let us consider the following case: A consumer using 100,000 kw.-hr. per month and having a demand of 450 kw. at 65 per cent power factor is billed for power in accordance with the rate shown in Fig. 2. In Table I the left-hand column shows the power factor of the installation after corrective equipment has been installed. Column 6 gives the cost of corrective motors required for the corresponding power factors. The motor sizes convenient to change to the corrective type are 50, 75, 100, and 150 hp., and Fynn-Weichsel motor prices are used, although the data in general apply to any type of synchronous motor. The installation cost has been omitted from consideration as this is an old installation and the value of the motors removed more than offsets the cost

Cost of Raising Power Factor, and Yearly Savings with Different Types of Corrective Equipment

TABLE I

(1) Final Power Factor, Per Cent	(2) R-Kva. Required to Raise from 65 Per Cent Power Factor	(3) Power Cost per Month	(4) Saving per Month	(5) Saving per Year	(6) Motor Cost	(7) Depreciation 15 Per Cent	(8) Operating Cost per Year	(9) Net Yearly Saving	(10) No. Years to Write Off Investment	(11) Yearly Return per Dollar per Year Invested
65	...	$2,500	....	......	....	....	(Not included)	......	....	.....
75	130	2,300	$200	$2,400	$1,888	$282		$2,118	.89	$1.12
85	252	2,160	340	4,080	4,348	650		3,430	1.27	.79
90	312	2,100	400	4,800	4,700	705		4,005	1.17	.85
95	383	2,050	450	5,400	5,930	890		4,510	1.31	.76
100	522	2,000	500	6,000	8,669	1,310		4,690	1.85	.54

TABLE II

(1) Final Power Factor, Per Cent	(2) R-Kva. Required to Raise from 65 Per Cent Power Factor	(3) Power Cost per Month	(4) Saving per Month	(5) Saving per Year	(6) Static Condenser Cost Installed	(7) Depreciation 15 Per Cent	(8) Operating Cost per Year	(9) Net Yearly Saving	(10) No. Years to Write Off Investment	(11) Yearly Return per Dollar per Year Invested
65	...	$2,500	....	......	....	....	(Not included)	......	....	......
75	130	2,300	$200	$2,400	$3,900	$ 585		$1,815	2.15	$0.465
85	252	2,160	340	4,080	7,560	1,130		2,950	2.56	.390
90	312	2,100	400	4,800	9,360	1,400		3,400	2.75	.364
95	383	2,050	450	5,400	11,490	1,725		3,675	3.12	.320
100	522	2,000	500	6,000	15,660	2,340		3,660	4.25	.234

TABLE III

(1) Final Power Factor, Per Cent	(2) R-Kva. Required to Raise from 65 Per Cent Power Factor	(3) Power Cost per Month	(4) Saving per Month	(5) Saving per Year	(6) Synchronous Condenser Cost Installed	(7) Depreciation 15 Per Cent	(8) Operating Cost per Year	(9) Net Yearly Saving	(10) No. Years to Write Off Investment	(11) Yearly Return per Dollar per Year Invested
65	...	$2,500	....	......	....	....	......	......	....	......
75	130	2,300	$200	$2,400	$3,000	$450	$828	$1,122	2.67	$0.374
85	252	2,160	340	4,080	4,600	690	1,296	2,094	2.20	.455
90	312	2,100	400	4,800	5,500	825	1,575	2,400	2.30	.437
95	383	2,050	450	5,400	6,000	900	1,907	2,593	2.31	.432
100	522	2,000	500	6,000	7,000	1,050	2,520	2,430	2.88	.347

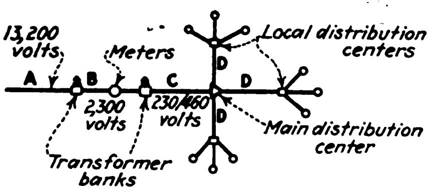


Fig. 1—Power factor corrective equipment may be applied at any one of several different points in a distribution system.

As may be desired, power factor may be corrected on the high- or low-voltage sides of the transformer bank, at the main distribution centers, or on the individual circuits.

of placing the new ones. Column 10 shows the time required to write off the investment in each case, and Column 11 shows the annual return per dollar invested. It will be seen at once that the increased investment necessary to raise the power factor from 95 per cent to 100 per cent is not justified, since the $2,739 additional investment brings a return of only $180 per year.

This discussion could be carried into further detail if the 15 per cent amortization charge on the corrective motors were compared to the somewhat lower charges against the old induction motors. However, if the induction motors have been in service more than 7 yrs. they have probably been written off the books. Even if they have been in only one year, the 15 per cent charged off can permissibly be deducted from the cost of corrective motors. This may be considered an academic discussion and for the present purposes may be dropped without serious error resulting in the calculations.

Correction by Condensers

Table II shows data on the use of static condensers for power factor correction at the same load as given in Table I. In this table the condenser losses have been neglected, although they will amount to a substantial total if the low-voltage type of condenser is used. If high-voltage condensers are installed the power factor losses will be present throughout the system and the low power factor will extend into the transformer bank. Hence, even with the high-voltage condensers, the losses must be charged against operating cost. It will readily be seen that correction beyond 90 per cent power factor is not justified, as an additional investment of $6,300 would be required to make an additional saving of $260 a year. The returns would be too low to make the investment profitable.

Table III shows the same data covering the use of synchronous condensers. The operating costs, given in column 8, do not include the labor required to operate and maintain the condenser, although this expense will probably be $300 a year or more. In this case it will be seen that correction beyond 95 per cent is not justified.

The data given in Tables I, II, and III are represented graphically in Fig. 3. The return per dollar of investment shown in column 11 is plotted against the power factor given in column 1. In this particular installation synchronous motors prove to be the most economical, the return ranging from somewhat over 100 per cent per year to a minimum of about 50 per cent.

Condensers as an Investment

The returns secured by the use of condensers is sufficient to justify their use although, as has been pointed out, in the case of the static type the cost for correction above 90 per cent cannot be justified, and the synchronous type ceases to be a good investment at 95 per cent correction.

The purpose of this somewhat detailed explanation of the problems connected with the selection of corrective equipment is to show the manner of attacking the problem and to call attention to the more important considerations. It will be obvious that no particular type of corrective apparatus is always best, for each situation is different; it is also quite apparent that care must be exercised to limit the investment in corrective equipment to the most economical point.

Operating men must be prepared

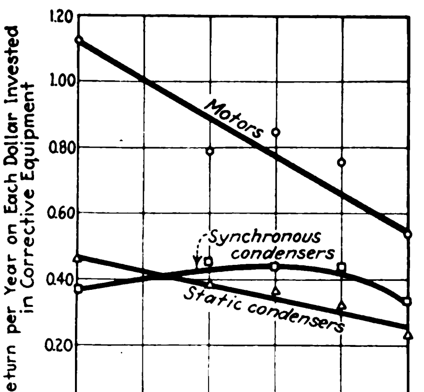


Fig. 3—These curves show the yearly return per dollar invested in the different types of corrective equipment. (See also Tables I, II and III.)

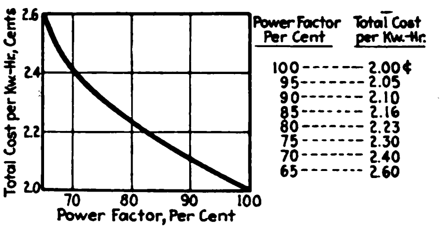


Fig. 2—This shows the relation between power factor and the cost of electrical energy per kilowatt-hour.

to meet the ever-increasing use of the so-called "preferential" power factor rate. And in a new installation—regardless of rates—careful consideration should be given to every factor that makes for operation at a high power factor.

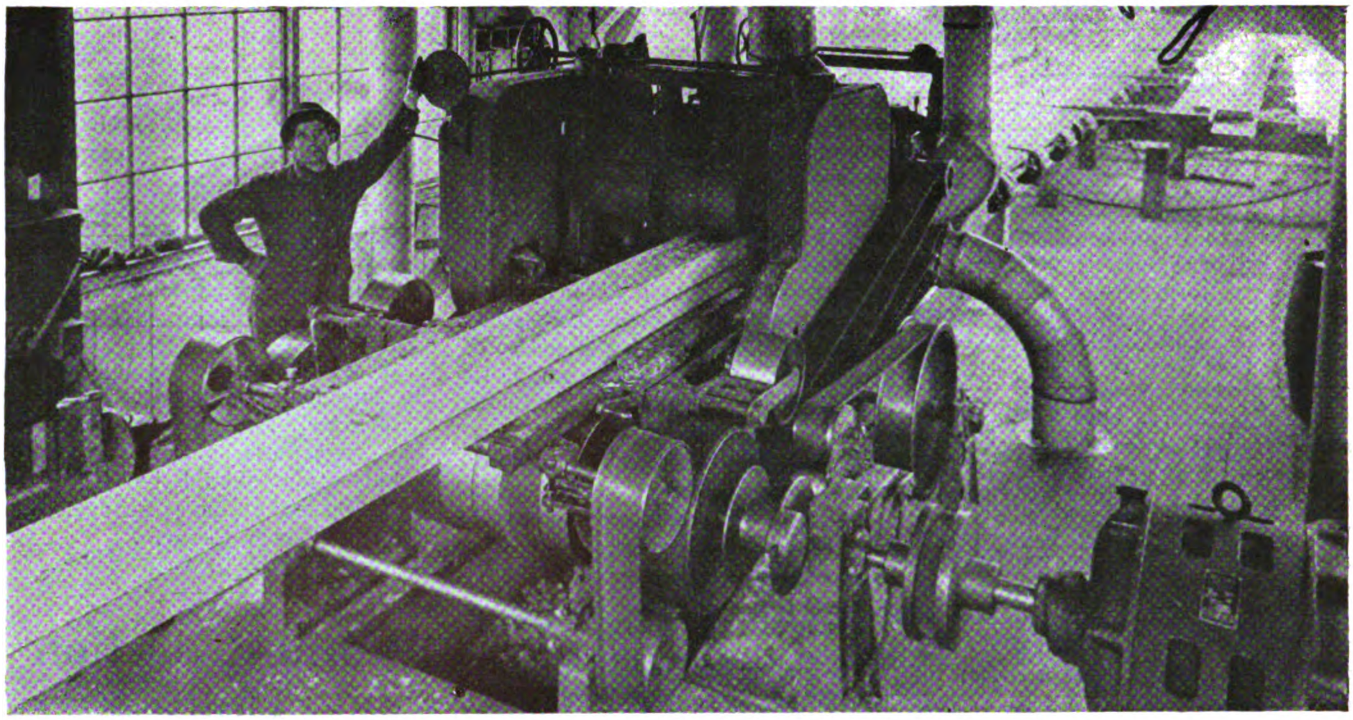
Worm Reduction Units

(Continued from page 8)

exceptionally heavy and high-grade roller and ball bearings are arranged to take the thrusts and radial loads due to an overhung pulley, pinion or sprocket on the gear shaft extension. No outboard bearing is necessary with this unit in order to handle overhung loads and it is therefore particularly adapted for use in cement mills, lumber mills, power plants and for general conveyor and elevator service where space is restricted and large reductions in speed are required.

Worm gear drives are now being used on a great variety of machinery, as for example, the chain draw-bench for wire shown on page 8. Here the heavy chain sprocket is connected to the gear shaft of the worm gear unit through a flexible coupling. Other metal forming machines such as the lighter rolling mills, foil mills, and machine tools such as the horizontal boring mill illustrated, are being driven through worm gearing. In many cases the worm reduction gearing is being incorporated in the design of various machine tools by manufacturers. In addition, many users are modernizing and improving their equipment by the addition of a reduction unit in the drive.

The worm gear unit is readily adaptable for the transmission of power under a great variety of conditions and where suitable it has become an efficient and dependable solution for many difficult power transmission problems.



Woodworking machinery, with its short turns and high speeds, demands a belt combining special flexibility with sufficient strength to afford a firm grip for fasteners.

POINTS TO REMEMBER

When Using

Rubber Transmission Belting

By C. F. CONNER
Engineer, Mechanical Sales Dept., The B. F. Goodrich Rubber Co., Akron, Ohio

RUBBER belting is distinctly an American development and its manufacture and application have progressed much further in this country than in any other. Government statistics show that the production of rubber transmission belting in this country, in spite of the increased use of motor drives, has been growing in the past few years. Rubber transmission belting has been in demand chiefly in the paper, mining, lumber and other basic-material industries where heavy machinery, intermittent loads, exposure to moisture and dust, and other adverse conditions have submitted it to the severest tests.

The higher qualities of rubber belting made today are much better able to withstand the deteriorating effects of age, heat, moisture and other influences than were the belts made a decade ago. The resistance to moisture afforded by rubber belting is well known, but its increased use is due not only to this quality, but also to its freedom from variations in length. The value of rubber as a filler for cotton fabric is due to its sealing the strands of cotton so completely that a rubber belt is comparatively free from any tendency to shrink and elongate with changes in humidity.

Among the more improved types of rubber belting are constructions in which the natural stretch of the cotton duck is largely removed in manufacture so that the completed belt is capable of transmitting heavy power loads with a minimum of take-up and adjustment to keep the belt tight on the pulleys. This has been reflected in a low maintenance cost and a steady transmission of power, so that in many applications the rubber belt has demonstrated a reliable capacity for service in addition to its advantageous first cost. Another distinctive feature of rubber belting is its capacity to retain its flexibility without treatment. Rubber belts require little or no breaking in and, when properly proportioned to the horsepower of the drive, seldom require the use of belt dressing.

The buyer will find it worth while to keep informed on improved belting constructions offered from time to time and to bear in mind that the inventive and engineering talent in the rubber industry, which for many years was concentrated on the development of the automobile tire, is now being applied also to the improvement of belting and other rubber products for industrial use, so that some important developments may logically be looked for at any time.

One important improvement already made is in the manufacture of factory-made endless belts. Rubber belts can now be built endless without splices or joints and have practically equal strength in all parts. The chief advantage of these endless belt constructions, however, lies in the fact that they stretch very little after being placed in service, so that, in many cases, they will run indefinitely on motor drives without reaching the limit of the motor take-up.

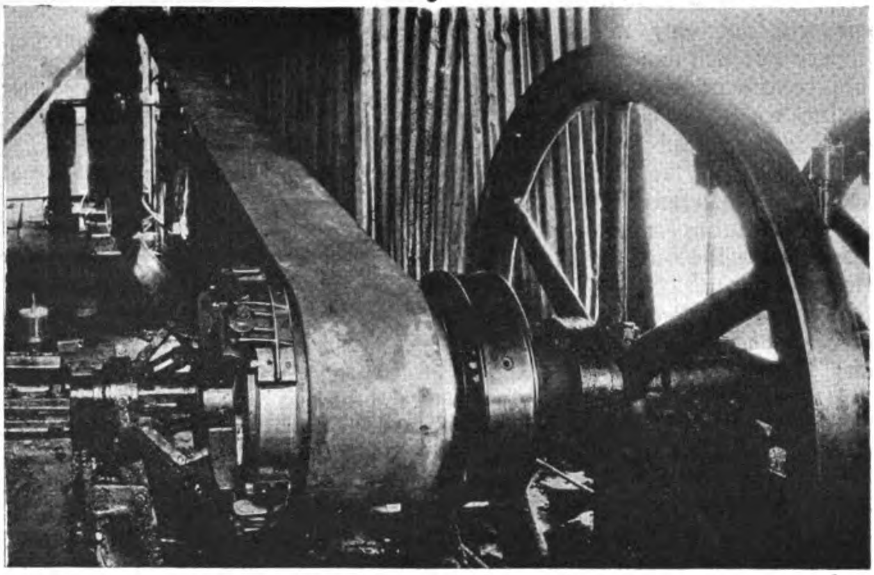
Until such time as more thorough tests are made of the power transmitting capacities of rubber belting, the best guide to their selection is

good judgment, which is based on service performance of particular brands under actual field conditions, plus the reputation of the manufacturer for quality products and progressive developments. This emphasizes the importance of service records.

Buyers of rubber transmission belting in large quantities have found that belts having the same superficial characteristics and selling at the same price may deliver service varying as much as 200 or 300 per cent. The only solution is the establishment of shop records showing the date of installation and the maintenance cost and life of each individual belt, particularly on the more critical drives. This point will be discussed at more length later in the article.

Method of Joining—When it is not practicable to use a factory-built endless rubber belt, the various popular types of metal fasteners serve satisfactorily, provided reasonable care is used in applying them. When plate fasteners are employed, the proper size should be used, as recommended by the manufacturer of the fastener for the particular thickness of belt and size of pulley. The use of oversize fasteners not only prevents smooth operation of the belt, but also strains the anchorage of the hooks and shortens the life of the joint.

All-metal hook fasteners used with rubber belts should be of the type which clinch across the lengthwise strands of the fabric. Leather lacings make an ideal joint for dry conditions, provided they are applied in a workmanlike manner. In punching a belt for lacings the holes should be as small as possible, otherwise the belt is weakened by severing the lengthwise strands.



Oil-well pump drives impose some of the most severe service conditions found in industry.

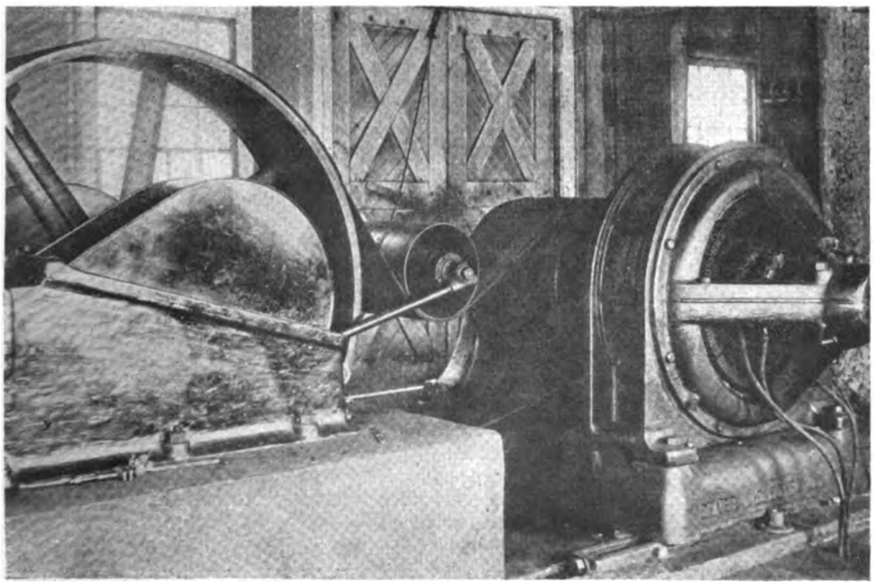
Here a 12-in., 6-ply rubber belt is used on a standard pumping rig in Arkansas. The owner of this oil well property was able to obtain more than 400 per cent increased service by adopting a belt of recently improved design at a 20 per cent higher initial cost per belt.

Initial Tension—A rubber belt should be applied with an initial tension of approximately 15 lb. per in. per ply. This is arrived at roughly by cutting the belt $\frac{1}{8}$ in. per ft. shorter than the tape-line measurement around the pulleys. Inasmuch as the stretch is not exactly uniform in various sizes and makes of rubber belt, this rule is not exact and in some cases an additional shortening will be found necessary. On vertical drives it is advisable to allow $\frac{1}{16}$ in. per ft. in cutting.

Limitations—The principal undesirable operating condition to be guarded against in applying rubber belting is excessive oil. Oils and greases, particularly mineral oils, have a solvent action on rubber which causes it to lose its sealing and adhesive properties in a relatively short time.

Treatments and Cleaning—Rubber belts, when new, sometimes have a white powder on the surface which may be either soapstone or the natural sulphur bloom coming out of the rubber. This usually does no harm, but if the belt, after applying under the proper tension, has a tendency to slip, its operation may be helped by the removal of this powder. This can be done by washing with soap and water or by a light rubbing with a gasoline-soaked cloth or waste. As a rule, however, this powder will disappear after the belt has been in service for a short time. The removal of the powder considerably increases the adhesion between the belt and the pulley.

Because of its permanent flexibility and pliability, rubber belting does not require regular dressing or treatment. If the surface becomes glazed and hard it can be softened by a very light application of vegetable castor oil or boiled linseed oil. Care must be taken not to use too



Here an endless rubber belt operates on a short-center drive in a colliery.

When installing rubber belts for the first time on this type of drive, it is important to specify the exact distance around the pulleys, with the idler down in *normal* position. Indicate to the belt manufacturer that he should make the necessary allowance for stretch. When ordered too short, a rubber belt does not stretch enough to let the idler drop into place and disastrous slipping results.

much, since too liberal an application will not only make the belt slippery but will damage the rubber. This treatment is best applied by holding waste or cloths, moistened with the oil, against the inner face of the belt. If belt dressings are used it is important to avoid dressings containing mineral oil or grease, as well as all dressings containing rosin.

Selecting the Proper Size of Belt for the Job—The first step to consider in selecting a belt for a particular drive is the question of availability. For example, an engineer when designing a drive would do better to use a 6-in., 5-ply belt than a 5-in., 6-ply belt even though it takes a wider pulley, inasmuch as a 6-in., 5-ply belt can be bought in stock almost anywhere, whereas a 5-in., 6-ply belt can seldom be obtained except on a special order from the factory, which naturally involves some inconvenience and delay. Table I lists the standard sizes of rubber belt obtainable in stock from branch houses and dealers.

Table I—Sizes of Rubber Belt Obtainable from Stock

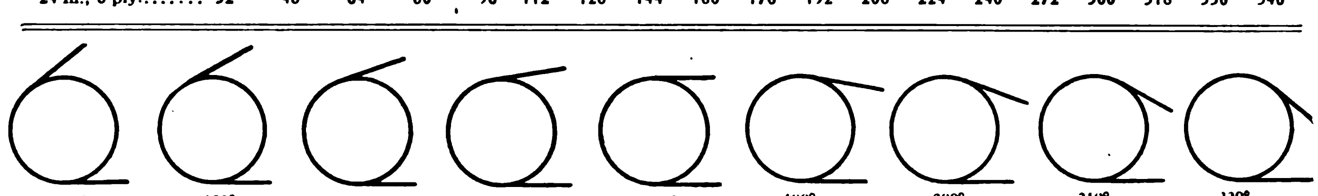
2 in. 3 ply	8 in. 5 ply
2 in. 4 ply	8 in. 6 ply
3 in. 3 ply	10 in. 5 ply
3 in. 4 ply	10 in. 6 ply
4 in. 4 ply	12 in. 5 ply
5 in. 4 ply	12 in. 6 ply
6 in. 4 ply	14 in. 6 ply
6 in. 5 ply	16 in. 6 ply

The question of the relation between the width and thickness of a belt depends largely on the type of drive. A 10-in., 5-ply belt, for example, might be preferable on a drive where pulleys are in alignment and other conditions insure equal distribution of the load across the width of the belt. On the other hand, for imperfect alignment conditions, such as produced by tapered

Table II—Horsepower Rating of Heavy Friction Surface Rubber Belts

(See note at the bottom of the table when selecting belt sizes.)

Size of Belt	Speed in Feet per Minute: 400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800	3,000	3,400	3,800	4,200	4,600	5,000
2 in., 3 ply	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8.5	9.4	10	10.3	10.6
2 in., 4 ply	1.3	2	2.7	3.3	4	4.7	5.3	6	6.7	7.3	8	8.7	9.3	10	11	12	13	14	15
3 in., 3 ply	1.5	2.3	3	3.8	4.5	5.3	6	6.8	7.5	8.3	9	9.8	10.5	11.3	12.8	14	14.8	15.4	16
3 in., 4 ply	2	3	4	5	6	7	8	9	10	11	12	13	14	15	17	19	20	21	22
4 in., 4 ply	2.7	4	5.3	6.7	8	9.3	11	12	13	15	16	17	18	20	23	25	26	27	28
4 in., 5 ply	3.3	5	6.7	8.3	10	12	13	15	17	18	20	22	23	25	28	32	34	35	36
5 in., 4 ply	3.3	5	6.7	8.3	10	12	13	15	17	18	20	22	23	25	28	32	34	35	36
5 in., 5 ply	4.2	6.2	8.3	11	13	15	17	19	21	23	25	27	29	31	35	39	42	43	44
6 in., 4 ply	4	6	8	10	12	14	16	18	20	22	24	26	28	30	34	38	40	41	42
6 in., 5 ply	5	7.5	10	13	15	18	20	23	25	28	30	33	35	38	43	47	50	52	53
6 in., 6 ply	6	9	12	15	18	21	24	27	30	33	36	39	42	45	51	56	60	62	64
8 in., 4 ply	5.3	8	11	13	16	19	21	24	27	29	32	35	37	40	45	50	53	55	57
8 in., 5 ply	6.7	10	13	17	20	23	27	30	33	37	40	43	47	50	57	62	66	69	71
8 in., 6 ply	8	12	16	20	24	28	32	36	40	44	48	52	56	60	68	75	80	84	86
8 in., 8 ply	11	16	21	27	32	37	43	48	54	59	64	69	75	80	91	100	106	110	113
10 in., 5 ply	8.3	13	17	21	25	29	33	38	42	46	50	54	58	62	71	78	83	87	89
10 in., 6 ply	10	15	20	25	30	35	40	45	50	55	60	65	70	75	85	93	99	103	106
10 in., 8 ply	13	20	27	33	40	47	53	60	67	73	80	87	93	100	113	125	133	138	142
12 in., 5 ply	10	15	20	25	30	35	40	45	50	55	60	65	70	75	85	93	99	103	106
12 in., 6 ply	12	18	24	30	36	42	48	54	60	66	72	78	84	90	102	112	119	123	127
12 in., 7 ply	14	21	28	35	42	49	56	63	70	77	84	91	98	105	119	131	139	144	148
12 in., 8 ply	16	24	32	40	48	56	64	72	80	88	96	104	112	120	136	150	159	165	170
14 in., 6 ply	14	21	28	35	42	49	56	63	70	77	84	91	98	105	119	131	139	144	148
14 in., 8 ply	19	23	37	47	56	65	75	84	93	103	112	121	131	140	159	175	186	194	200
16 in., 6 ply	16	24	32	40	48	56	64	72	80	88	96	104	112	120	136	150	159	165	170
16 in., 8 ply	22	32	43	53	64	75	85	96	107	117	128	139	150	160	181	200	213	222	229
18 in., 6 ply	18	27	36	45	54	63	72	81	90	99	108	117	126	135	153	168	180	186	192
18 in., 8 ply	24	36	48	60	72	84	96	108	120	132	144	156	168	180	204	224	238	246	254
20 in., 6 ply	20	30	40	50	60	70	80	90	100	110	120	130	140	150	170	186	198	206	212
20 in., 8 ply	26	40	54	66	80	94	106	120	134	146	160	174	186	200	226	250	266	276	284
22 in., 6 ply	22	33	44	55	66	77	88	99	110	121	132	143	154	165	187	205	219	226	233
22 in., 8 ply	28	44	59	73	88	103	116	132	147	160	176	191	204	220	248	275	292	303	312
24 in., 8 ply	32	48	64	80	96	112	128	144	160	176	192	208	224	240	272	300	318	330	340



140° Subtract 17% — 150° Subtract 13% — 160° Subtract 8% — 170° Subtract 4% — 180° Rating of Rule I — 190° Add 4% — 200° Add 8% — 210° Add 11% — 220° Add 15%

NOTE—This table is based on a 180-deg. arc of contact. Where the arc of contact is greater or less, due to unequal pulley diameters, the value as given by the table should be increased or decreased according to the values indicated in the above chart, which gives the percentage correction for each 10 deg. from 140-deg. to 220-deg. arc of contact. The rating at 180 deg. is based on Rule 1 which is that a heavy, friction-surfaced rubber belt will transmit 1 hp. for each ply of fabric 1 in. wide at a speed of 2,400 f.p.m., and at other speeds in proportion. For high speeds deductions are made in this table from this basis of rating according to the rule to obtain the values given in the last two columns. Ratings at higher belt speeds than given in this table may be obtained as follows: For speeds of 5,000 to 5,500 f.p.m. use the ratings in the table for 5,000 f.p.m.; for speeds between 5,500 and 6,000 f.p.m. use the rating for 4,600 f.p.m. The sizes of belts which are set in bold type in the first column are the commercial or stock sizes which are carried in stock by belt houses. Whenever possible a commercial size should be used because the special sizes must be obtained directly from the manufacturer.

cone pulleys or quarter turns, an 8-in., 6-ply belt would operate more satisfactorily.

Strength and Thickness—When determining the size of a rubber belt or substituting it for leather we assume the tensile strength of rubber belts to be equal to leather in corresponding thicknesses. The following table shows a thickness comparison between friction-surface rubber belts and leather belts:

Rubber Belt	Corresponding Leather Belt
4 ply	medium single
5 ply	heavy single or light double
6 ply	medium double
7 ply	heavy double
8 ply	three ply

Horsepower Rating—Table II affords a convenient and simple means by which it is possible for an industrial man to determine quickly the horsepower rating of all sizes of rubber belt commonly used, with a minimum of calculation. A simple rule for mental calculation is the following: A heavy, friction-surface rubber belt will carry 1 hp. for each ply of fabric 1 in. wide at a speed of 2,400 f.p.m. The rating for other speeds is in proportion. The results obtained by this rule should be corrected for high speeds, as follows: At 4,500 f.p.m., deduct 5 per cent from rating; at 5,000 f.p.m., deduct 10 per cent; at 6,000 f.p.m., deduct 25 per cent.

This correction, while only approximate, will be found in practice to provide sufficient allowance for the loss of pulley grip due to centrifugal force. The result should be also corrected for arc of contact, in accordance with the correction factors at the bottom of Table II.

These simple rules, if fixed in the memory, will be found extremely practicable and dependable. Any method of calculation, no matter how elaborate, is at best only an approximation because certain important factors, such as initial tension and coefficient of friction, are seldom known exactly and have to be taken for granted. Those who depend on tables and charts are lost when these are mislaid. The man who carries the rule in his head never has to resort to guesswork and will save

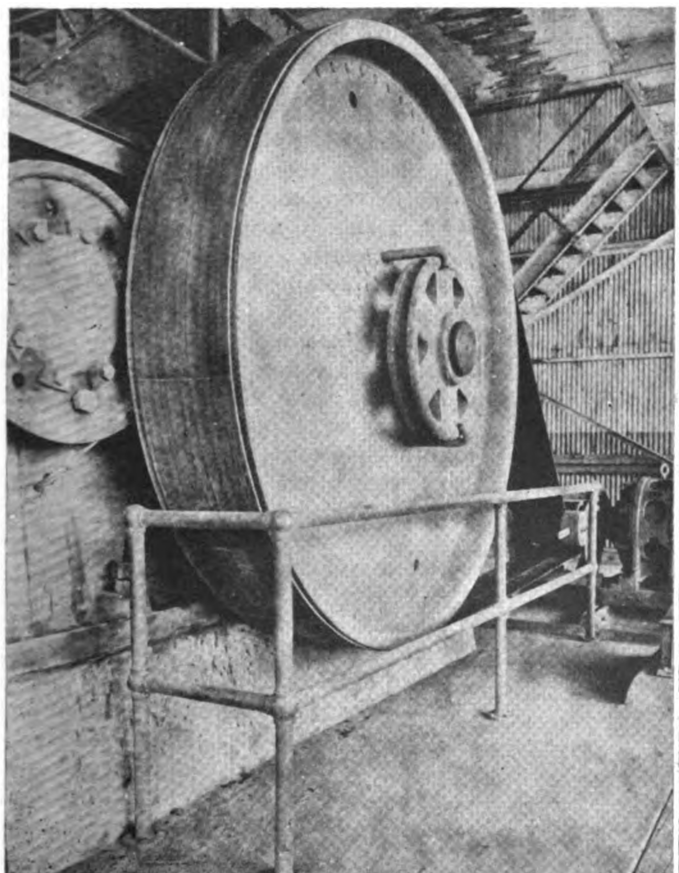
Table III—Minimum Pulley Diameters Recommended for Special Flexible Rubber Belts*

No. of Plies	Belt Speed in Feet per Minute					
	1,000	2,000	3,000	4,000	5,000	6,000
4	4 in.	4 in.	5 in.	6 in.	6 in.	7 in.
5	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.
6	10 in.	11 in.	12 in.	14 in.	15 in.	17 in.
8	17 in.	19 in.	22 in.	24 in.	27 in.	29 in.

*This table is based on the manufacturer's recommendations for rubber belts of special flexible construction designed for small pulleys. Where belts of regular construction are to be used, these diameters should be increased one-third.

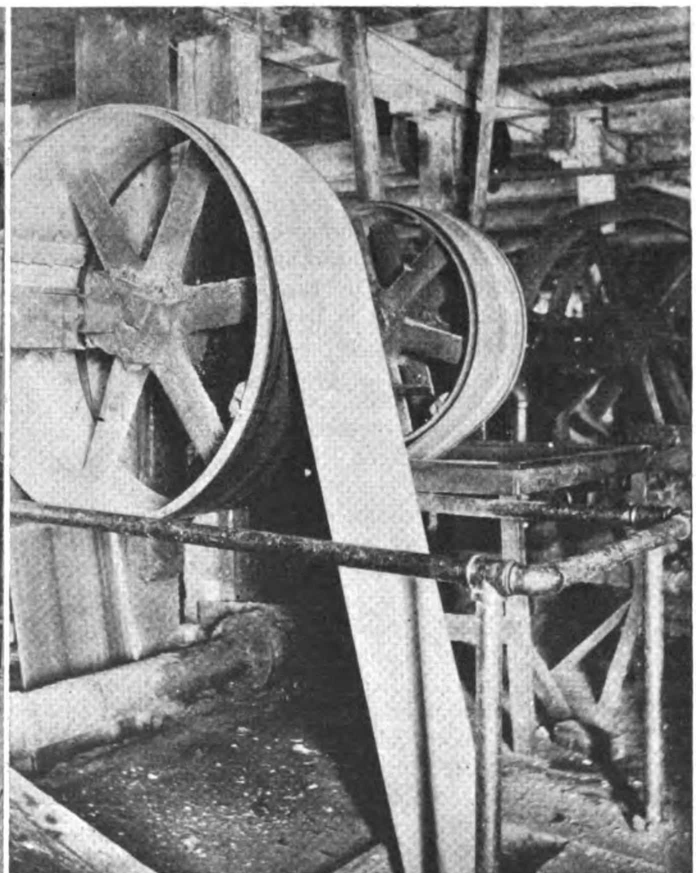
An example of an endless rubber belt operating on a crusher drive in a copper ore concentrating mill.

The motor take-up was adjusted twice in nine months, the total stretch being only 4 in. This is a 20-in., 5-ply heavy endless rubber belt 52 ft. long. The pulley on the 125-hp. motor is 17x21 in. with ¼-in. crown and operates at 860 r.p.m. The driven pulley is 110x21 in. This is operated with a short-center drive at 10-ft. centers.



A typical paper mill drive operating a line of beaters.

This is a 20-in., 6-ply rubber belt 44 ft. 6 in. long. These drives impose severe service on belts on account of the slow speed which is common practice in old mills.



himself much trouble from misapplications.

For example, an industrial operating man who carries the foregoing horsepower rule in mind knows instantly that an 8-in., 5-ply belt is rated at 40 hp. at a speed of 2,400 f.p.m. If it is to be applied on a drive where it will travel at 3,600 f.p.m., he knows its rating would be just 50 per cent greater, or 60 hp. By familiarity with the angles of various arcs of contact, as illustrated in the chart at the bottom of Table II, he can quickly make the proper allowances by deducting or adding an approximate percentage for correction because of the improper working conditions.

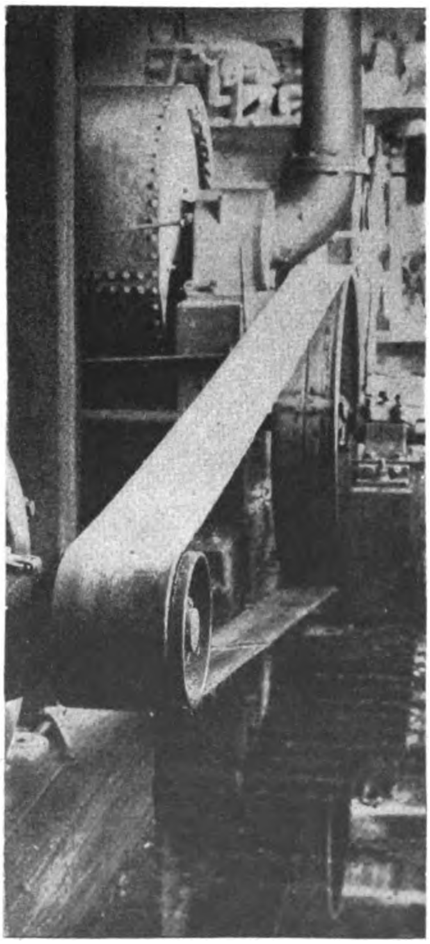
Calculation of Belt Speeds—The calculation of belt speed also lends itself to mental arithmetic by simply multiplying the pulley diameter *in feet* by 3 and then by the r.p.m. of the shaft on which the pulley is mounted. The result is within 5 per cent of the correct speed and is close enough for most purposes when estimating horsepower. When necessary to know the exact belt speed, multiply the pulley diameter in feet by 3.142 instead of 3. If the diameter used is in inches the product must be divided by 12 to get feet.

Minimum Pulley Diameter—The proper relation between the pulley diameter and belt thickness should be kept constantly in mind in deciding on the size of belt to use. An old-time rule, used in the early days of belt manufacture, was to allow 4 in. of pulley diameter per ply of belt. This rule has become obsolete, however, with the increased use of small motor pulleys and the improvement in rubber belts. On the other hand, belt distortion due to rapid bending over small pulleys is likely to cause "bootlegging" or ply separation.

Ample pulley diameters, when practicable, are a good investment, which is reflected in longer life of belts. When possible it is advisable to allow 3 in. of pulley diameter per ply and for speeds above 4,000 f.p.m., 4 in. per ply. When this proportion cannot be maintained, it is advisable to use a high-quality rubber belt recommended by the manufacturer for small-pulley work. Table III is typical of the recommendations of various leading manufacturers of rubber belts on minimum pulley diameters. These recommendations are graduated according to the speed of the belt, as the deteriorating effect is proportional to the frequency of bending as well as to the diameter of the pulley. For this reason a more liberal allowance should be made for drives with abnormally short centers.

Belt Maintenance—As a rule the most important aim in belt maintenance is to avoid shutdowns and production delays due to belt troubles. Prevention of such mishaps can easily pay the cost of assigning to one man the job of watching all drives and taking the responsibility for the condition of all belts. The saving on belt purchases which may be brought about by a good man in such a position, while incidental to the more important aim of promoting steady production, can in itself amount to a considerable figure.

The greatest obstacle against the adoption of such a plan is the difficulty experienced in maintaining such supervision during night shifts. An assistant belt man should then be on the job and responsible to the day man. Such plans have also come to grief, in many cases, through an attempt to do the job too thoroughly and trying to maintain records so elaborate as to be impracticable.



This "hog" refiner drive is a typical example of the adaptability of rubber belts to wet conditions.

It should be sufficient to have each drive numbered and tagged and a record kept showing the following information: (1) Number or name of drive. (2) Department. (3) Exact length belt should be cut. (4) Width. (5) Number of plies. (6) Make of belt. (7) Date purchased. (8) Date applied. (9) Date removed. (10) Date when motor take-up is adjusted, and number of inches motor is moved. (11) Date when belt is replaced, and number of inches taken out. (12) Remarks.

Engineering and Maintenance Department records should be in such shape that a belt man can easily ascertain any desired data on a drive, such as speed of shafts, diameter and width of pulleys, horsepower, and so on, from the records and not have to go out into the plant and shut down a machine to get it. The lack of such records in a plant often necessitates some broad guesswork and is a common cause of belt misapplication.

Belt Failures—One of the inherent advantages of rubber belt is the fact that the nature of the materials and the method of manufacture reduce the possibility of defects to a very small percentage. If examination shows that the friction adhesion is still strong and elastic, the failure can usually be traced to misapplication or bad operating conditions. When a belt fails prematurely, it is a good plan to save it, even though no claim is to be made against the manufacturer, until the belt salesman makes his next round. After inspecting the old belt and studying the drive conditions the salesman is often able to make suggestions that will greatly increase the future service obtained on that particular drive.

The great majority of rubber belt failures are due to fastener trouble. Many of them might be avoided by the use of a belt square when cutting open-end belts. Even a small fraction of an inch of variation in the ends of a belt may throw an uneven strain on one or two hooks, which results in a bad joint.

Storing Rubber Belts—The better qualities of rubber belting as manufactured today are not susceptible to rapid deterioration. It is advisable, however, to give some attention to storage conditions. Light is probably the most destructive factor in its effect on rubber, particularly direct sunlight. Also, belts should not be stored in hot places nor in wet places.

A general view of the interior of the machine shop.

The ample daylight illumination obtained is largely due to the extensive use of continuous sash in the wall area. The main bay in the foreground is 75 ft. by 150 ft. with 35 ft. clear underneath the crane. The lean-to at the right is 40 ft. wide with a clear height of 20 ft. underneath the crane. The stairway to the crane runway is shown in the front corner of the main bay, ending near the letter M. This view indicates in a general way the size of the machine tools, the arrangement of the floor and building, and something of the variety of work handled. The artificial lighting is illustrated more clearly in an accompanying illustration.

Unique features of

LIGHTING SYSTEM for Large Machine Shop

in which unusual service conditions are encountered

By JAMES THOMSON

Chief Engineer, Hubbard Steel Foundry Company, East Chicago, Ind.

THE steel foundry which I am associated with recently erected a large machine shop to do jobbing work on the castings made for our customers. These castings consist largely of iron, steel, and alloy steel rolls for rolling mills, steel gears of large dimensions, and large steel castings for rolling mills, special machinery, locomotives, and cars. Much of this work is of such large size or unusual shape that the customers have no shop facilities capable of handling their castings.

The housing, power servicing, and lighting of the heavy machinery required unusual provisions for effective operation. The machinery installed consisted of two groups: Extra-heavy boring mills, radial drills, planers, and other such machines made up one group; the other group consisted of lathes, milling machines and other ordinary shop tools for the handling of the lighter castings. It was decided to separate these groups because of the different building facilities and operating requirements which would be necessary.

Adequate lighting and ample floor space for storing the large castings near the machine were two of the principal considerations affecting the design of the building. It was finally decided to erect a steel-frame building which consists of a large main bay, 150 ft. by 75 ft. with a clear height of 35 ft. underneath the 30-ton Shaw crane, and a 40-ft. lean-to on the north side extending the full length of the building, with a clear height of 20 ft. beneath the smaller 5-ton Milwaukee crane. The main aisle, however, is capable of accommodating a 50-ton crane. The larger machine tools are placed in the main bay and the smaller ones in the lean-to. The general arrangement is such that the machine tools are located around the outer edge of the bays and the center of the floor is left vacant for temporary storage of castings, before and after machining. How this location of machine tools affects the lighting will be brought out later in the article.

Daytime lighting is provided by the natural light through the large area of continuous steel sash which extends practically all of the way around the building. As the lean-to is on the north side of the building the entire south wall of the main bay and the ends offer an uninterrupted exposure to daylight. Up to this time (the shop was put in operation during August of last year) there has been but little necessity of using artificial light except a few times in the late afternoon and at night.

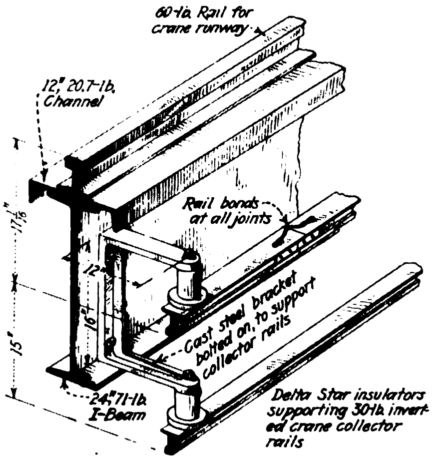
Artificial light is provided by a system of general illumination in which the lighting units are so placed and controlled that when nec-

essary only small sections of the shop, such as around a single machine, need be illuminated. There are no individual lights on any machine. The illumination of the main bay is obtained from a number of 500-watt lamps mounted on the columns at each side of the bay and below the collector rails. Other 750-watt lamps are mounted on the roof trusses and above the craneway. The 500-watt side lamps are installed in Benjamin Electric Company elliptical, porcelain-enameled steel, angle reflectors. The 750-watt lamps are placed in Benjamin deep-bowl, porcelain-enameled steel, railroad-type reflectors.

The side lights are about 30 ft. above the floor level and the special elliptical shape of the reflector directs the light along the side of the bay and around the machine tools, instead of out toward the center of the floor area, which is used for temporary storage. The central area is lighted from the overhead units which also spread their light over the whole width of the bay and so eliminate shadows which would result if only the sidelights were used. Also, the center lights furnish sufficient general illumination for crane service and any other activities that are carried on in other parts of the building away from the machine tools.

The lean-to bay is lighted by 500-watt lamps in Banjamin railroad-type, deep-bowl, porcelain-enameled steel reflectors located on the roof trusses about 22 ft. above the floor level.

All lamps are mounted on Thompson safety lowering switch hangers (Thompson Electric Co., Cleveland, Ohio) to facilitate renewal or cleaning. The chain which supports each lamp unit is enclosed in conduit, which is mounted alongside the column as indicated by *A* in the illustration on this page. The ring in the end of the chain is hooked in a



This sketch shows the method of mounting the collector rails for the crane.

A cast-steel bracket, which is bolted to the I-beam supporting the crane runway, has two collector rails fastened to it in an inverted position with insulators between. The cast-steel bracket prevents breakage, and no dust can collect on the rails as they are placed upside down.

Thompson enclosed fitting Type 65, which may be secured with a padlock through the staple.

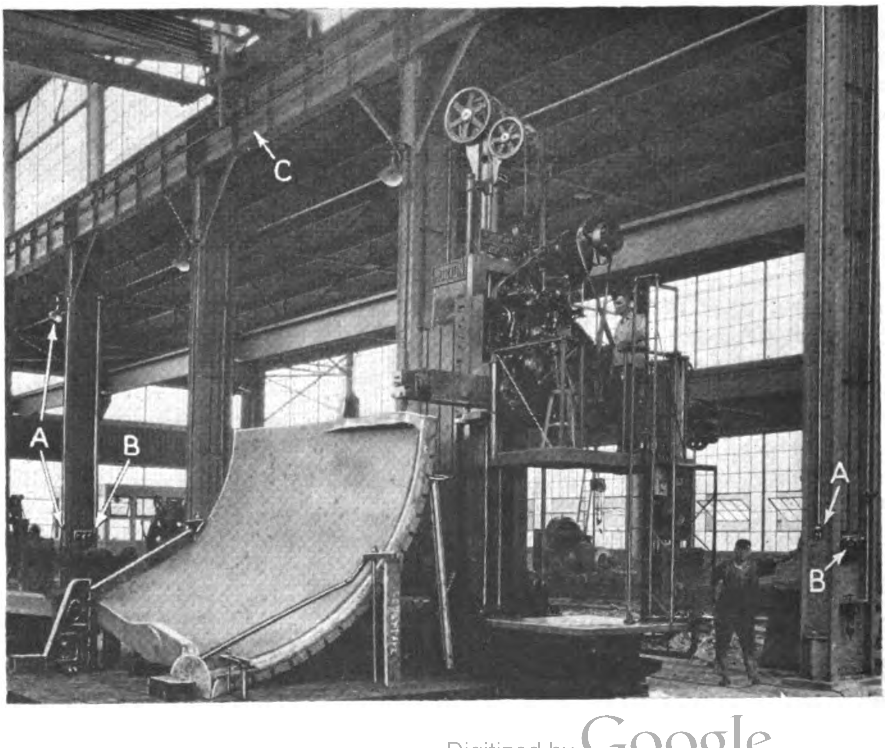
To service lamps, it is necessary only to snap a rope into the ring on the end of the chain, loosen the disconnecting device and lower the lamp and reflector to the floor. The lamp and reflector units in the roof trusses are serviced in a similar manner by lowering them to the crane bridge. With such facilities all lamps can be cleaned as often as necessary and because of the ease of doing so, they are more likely to be serviced properly. The installation has not yet been operating a sufficient length of time to establish a cleaning and servicing schedule.

Another interesting feature in the control of the lighting units is that each light is operated from an individual switch, instead of in groups, except in the lean-to where two lights are on one switch. The three switches for controlling the lamps in the center of the main bay, the side lamps with elliptical reflectors, and the lamps in the roof truss of the lean-to at the right are indicated at *B* in the illustration on this page. The switches for the elliptical angle reflectors on the other side of the main bay are located on the building columns which support the reflectors. These switches are the V and V series MS, 20-amp., 250-volt rating, manufactured by the VV Fittings Company, Philadelphia, Pa., and are dust- and moisture-tight and fused.

The incoming lighting circuits, one for each row of lamps, are brought in at the end of the building through Type DF, VV Fittings Company, 60-amp. switches.

Connections for air lines with a strainer and blowoff cock are mounted on the columns just below the switches indicated at *B*.

Power for the machine shop and the cranes is obtained at 230 volts, direct current, from two rotary converters. Power is received from the Northern Indiana Gas & Electric Company at 11,000 volts, three phase, 60 cycles and is stepped down to 440 volts for general plant use through three single - phase transformers.



A closer view of one of the machines and lighting arrangement.

Special elliptical, angle reflectors are mounted on each column below the crane runway and controlled from a switch on that column. In addition, lights are placed in the center of the truss above the crane. The lean-to is illuminated by a single row of lamps placed in the center of the roof truss upon the crane way. All lamps are serviced by lowering them with a Thompson disconnecting switch to the floor. The fitting for controlling the lowering of the lamp is shown at *A*. The lighting switches, one for each lamp, are shown on the column at *B*. *C* indicates the location of the crane collector rails which are shown in more detail in the accompanying sketch.

Further reduction to 110 volts for the lighting circuits is made through three 10-kva. General Electric Type H transformers.

All machine tools and the cranes in the machine shops are operated by 230-volt, direct-current motors, most of which are of the variable-speed type. Practically all of the motors came with the machine tools, and so are of various makes and sizes. The motor control, in almost all cases, is of the automatic, push-button type supplied by the Electric Controller & Mfg. Co., Cleveland, Ohio.

Conduit lines to the various machines are set in the concrete floor as it was not desired to bring any overhead obstructions into the crane-way. The concrete floor is surfaced with Kreolite wood blocks which are covered and the cracks filled with an asphaltic preparation poured on while hot.

The method of mounting the crane collector rails is somewhat unusual and was designed to prevent the difficulties which result from dust settling on the surface of the rails. This is overcome by mounting the collector rails upside down as shown in the accompanying sketch and at *C* in the illustration on page 18. The 30-lb. collector rails are fastened to the I-beam runways by suspending them from cast-steel brackets by means of Delta-Star type 10340 insulators. We made a pattern and cast the brackets of steel in our foundry. I believe that even if it were necessary to have these brackets made outside, as would be the case where industrial plants do not have a steel foundry, it would pay to have them made of cast steel instead of cast iron as the difference in cost would be more than overcome by the security from breaking. This mounting, I believe, will prevent breakage and eliminate dust trouble, which are two of the more common troubles in connection with crane operation. The 30-lb. collector rails are joined electrically by rail bonds welded on in order to insure a good connection at all times.

As an extra precaution for safety, stairways are used instead of ladders to the crane runway. One of these stairways may be seen at the front of the building in the illustration at the beginning of this article.

Factors That Influence Origin and Extent of Dust Explosions

PLANT construction is related closely to the origin and extent of dust explosions, as will be noted from extracts of a paper by David J. Price, engineer in charge of development work, Bureau of Chemistry, read at Technical Sessions, Chemical Equipment and Process Engineering Exposition, Cleveland, Ohio. In a number of explosions, the value of certain types of construction, for example large window glass areas, has been well demonstrated. In a chemical plant, for instance, the dust-explosion hazard exists in practically all types of processes, such as transporting, energizing, reacting, separating and conditioning. In the transporting process, explosions may originate in the elevators, conveyors, loading and unloading machines, and in practically all types of material handling and conveying equipment.

Fires and explosions have occurred in driers when the temperature has been considerably below the ignition temperature of the material. The question is, What causes these fires? Does prolonged heating at comparatively low temperatures change the chemical composition of grain dust, wood dust, and starch so that the resulting material has an ignition temperature lower than that of the original dust? Some work is being done on this problem by the Bureau of Chemistry at the present time, but no definite conclusions have as yet been reached.

Certain factors contribute to the explosibility of a dust, one of the principal factors being the degree of fineness. Flame propagates rapidly through a 200-mesh cloud, and the rate of flame propagation appears to increase in proportion to the relative degree of fineness. Based on the results of recent work by Bouton and Hayner, it appears, however, that there is a limit to this relationship of fineness to flammability. Recent experiments with two types of coal, one from the Pittsburgh bed in Pennsylvania and the other from the Pocahontas bed in West Virginia, were conducted to obtain a quantitative relationship between fineness of dust and its tendency to flare up when suspended as a cloud and ignited at some point. In reporting this work the investigators state: "The experiments gave the unexpected result that flammability does not increase indefinitely with fineness but seems to reach a maximum and then fall off, or at least remains constant, as the fineness is still further increased."

The design of dust collecting systems is vitally important in this dust explosion problem. In some instances explosions have occurred in the dust collecting pipes and also in the dust collector. The successful collection of dust by mechanical equipment (in the handling by fans and pipes) bears a close relation to the explosive concentration limits. In the design of these dust collecting systems it is essential that engineers be fully acquainted with the dust explosion hazard and the conditions under which the dusts can be ignited and flame propagated.

At present the relation of relative humidity to explosion frequency is receiving much attention. It has been claimed that the explosion hazard will be reduced by an increase in the relative humidity. So far the work done on this phase of the problem has been limited. It appears, however, that it cannot be generally claimed that an increase in relative humidity will entirely eliminate the dust explosion hazard.

It is true that with increased humidity the possibility of formation of static electricity may be reduced, owing to the thin film of moisture which acts as a conductor for the static electricity, thus permitting the charges to be neutralized or grounded. There are engineers who feel that much protection can be afforded by the introduction of a humidity control system and that the entire subject is a matter for further research.

Dust explosions occur in what may be termed two stages: primary and secondary. A primary explosion is usually an ignition of a small quantity of dust with localized effect. The concussion accompanying this original ignition, however, is sufficient to shake into the air any settled or collected dust, resulting in a rapid propagation of flame and in what is termed a secondary explosion. In this explosion a considerable pressured is developed and as a rule the plant is badly damaged.

The need of effective dust-removal systems for both suspended and

static dust is, therefore, shown. By efficient dust removal the propagation of flame is prevented and the secondary explosion, as a rule, limited in extent. Progress has been made recently in the development of pneumatic cleaning systems for the removal of settled dust throughout the plant. It has been demonstrated that proper maintenance and "good housekeeping" are essential in dust explosion control.

Method of Conveying Steel Chips by High Air Velocity

THE hand sorting of finished automatic screw machine work from its waste, the chip, is about the least desirable job in modern industry. In our plant between 500 and 600 tons of steel shavings are run each year from our automatic screw machine room.

The shavings, work, and what oil comes from it, are raked into low pans on truck wheels. The material is then shoveled into the centrifugal extractor pans where the oil is whirled out and recovered. Formerly, the extractor pan was dumped into screen-bottom hand shakers on casters running on an angle-iron track. After the fine chips had fallen through the screen into the dump box truck, the large chips were picked out, and then the work was picked out and placed in "tote" boxes. When the dump box was full, it was run up one flight on the elevator and out on a runway over the chip pile, and dumped. This job of sorting and extracting kept four men busy, and the labor turnover was an ever-present problem.

Our company bought a McKenzie separator, and this, of course, did its own sorting, but the bulk of the chips and shavings was delivered about 2 ft. from the floor highly inflated, which condition was due to the air blast of the separator. Therefore, although we did not have to sort the finished work from the chips, we did have the extra operation of shoveling the chips from the floor into a dump box truck. So we set out to devise some method which would automatically handle the chips, in place of shoveling them.

In our unused, obsolete machine building (aptly named the Morgue) we had a No. 5 B. F. Sturtevant forge blower which would give us a good, high-pressure air blast; so it was decided to use this blower in a small experimental model that was built to remove chips. As the model worked satisfactorily, we then went ahead and built and installed a machine to remove the chips.

As the McKenzie separator is rather high for easy loading, it was lowered into the floor, bringing the loading tray down to the 3-ft. level, or about on a level with the top of the extractor. The room is on the ground floor and there is no basement; so it was necessary to bury the conveyor pipe under the cement floor from the conveyor to the outside wall of the building. Where the conveyor pipe is buried under the cement floor, it is surrounded by a 10-in. tile pipe which is cemented into the floor. The conveyor pipe inside the tile pipe is made of No. 16 9-in. galvanized iron removable liners so that this part of the conveyor pipe can be easily removed from time to time as it wears and needs to be replaced.

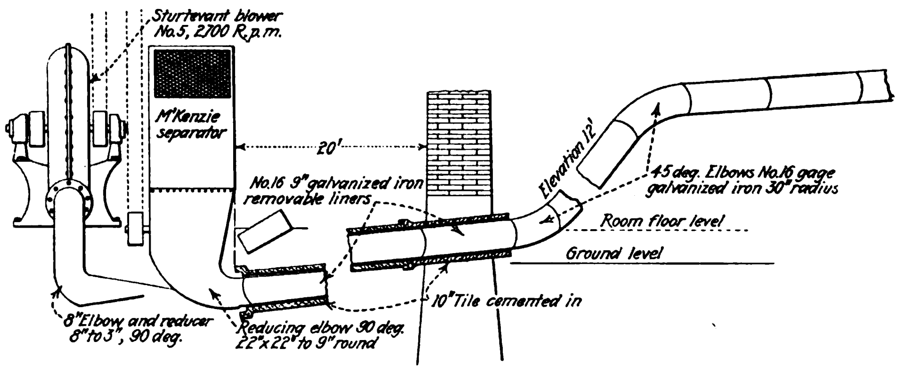
In order to collect the chips as they are discharged from the separator a reducing 90-deg. elbow was made, it being 22 in. square at the top and where it connects to the separator and 9 in. in diameter at the bottom end where the chips are directed into the conveyor pipe. The Sturtevant blower was next lined up parallel to the separator, the blower being driven at 1,800 r.p.m. by the same counter-shaft that drives the separator. The discharge pipe of the blower was connected to the large, reducing elbow on the separator by a 90-deg. round elbow, reducing from 8 in. to 3 in. The blower elbow connects with the larger one at a point close to the end of the tile which surrounds the conveyor pipe, as shown in the accompanying illustration. The discharge end of the conveyor pipe was elevated about 12 ft. above the floor level.

As the boxes and arbor were not in good condition, they would not stand the speed necessary to produce the strong blast needed. Therefore, it was decided to do what we have found to be an economical practice in the long run; that is, to install ball bearings. A set of Fafnir bearings was installed on this job, and the speed raised to 2,700 r.p.m. All ran well for two months when it was discovered that the tile had been cut so badly as to cause the system to plug up. The original iron pipe installed was of No. 22 gage, and it was also badly cut, particularly at the elbows. The weight of metal was increased to No. 16 gage, and the tile was lined with one soldered length of No. 16 gage, 9-in. galvanized iron pipe which was soldered in order to facilitate removal if necessary.

The system has now been running for two years, and has reduced the labor cost in that room 50 per cent, for two men now do what was formerly accomplished by four men. Maintenance costs are low, and the labor turnover problem has been eliminated. What was once a very undesirable job, is now a good one.

Combined separator and chip conveyor.

The conveyor pipe rises to an elevation of 12 ft. and the chips are piled to a height of 20 ft. The 10-hp. motor which drives the blower and the separator is sufficiently large to force the chips a total distance of 125 ft.



A point to remember in connection with a discharge pipe of this sort is to make the turns in the pipe as long as possible, it being generally advisable to use a 30-in. radius on a 9-in. line, for long bends have a tendency to reduce the wear at the elbows. If different conditions are encountered on a new job, it will only be necessary to make a few minor changes in the construction as shown here, for the principle of design would remain the same.

Plant Engineer, R. J. COLLINS.
Millers Falls Co.,
Millers Falls, Mass.

Mush Coils for A.C. and D.C. Motor Windings

together with complete data in tabular form that give details of these coils in the types used in different designs of motor windings

By A. C. ROE
and
D. H. BRAYMER
Consulting editor, Industrial Engineer

THE PRECEDING article of this series, which appeared in the December issue, dealt with the general applications of mush or hit-and-miss coils and gave some pointers on winding rules for the different types. In this article more details are given on the construction, shaping and insulation of these coils for direct- and alternating-current windings. The tables give the essential features of the coils discussed and refer to the photographs, which show particular features of construction.

THE types of mush coils that were discussed in the December, 1926, issue, and will be further dealt with in this article, can be divided into three general types, as follows:

(1) Flat mush (*M.*)
(2) Mush pulled coils (*M-P.*)
(3) Involute mush (*I-M.*)

The letters in parentheses indicate the symbols used with each type of coil in what follows.

Each of the above types of mush coils can be divided into other types. For example, in the "flat mush," we have the basket winding coil, two-layer diamond coil, and the rectangular-shaped coil for bipolar, d.c. armatures using the staggered or in-and-out winding. These are also arranged according to the shape and methods of bringing out the leads and ways of taping. The details of construction will be shown in photographs with insulation specifications furnished for each type.

In the "mush pulled" coil we have stator and rotor coils with different methods of bringing out the leads and taping.

In the "involute" class also, the leads and taping are the distinguishing features.

With each type of coil shown in the photographs a symbol is used such as M-1, M-2, etc. The accompanying tables list these different types and the methods of winding, insulating, etc. These tables with symbols and photographs will constitute a master manufacturing and insulating information chart that will enable the coil man to call for any mush type of coil by symbol number and have it wound and insulated as desired. This will reduce the writing up of coil orders to a minimum.

Flat Mush Coils Used in D.C. Windings.—Fig. 1 shows a flat mush coil (M-6) with the leads brought out from the end of each slot section. This type is used principally on direct-current armatures and the leads per coil side are divided up into as many groups of conductors as the number of bars divided by the total number of slots. The number of wires per sleeve is equal to one-half the total number of active wires per commutator bar. The term *active wires per bar* is used to account for dummies. That is, suppose we have a commutator and on inspecting the front of the neck of any one bar we find eight wires. On checking the rear of this bar we find four wires leading from the neck to the winding. We then know that this commutator has four active wires per bar and four dummy wires per bar, and since the leads of any direct-current armature are arranged in two layers (top and bottom leads) we know that each top and bottom lead will have two wires per sleeve, or that the conductor of each single coil consists of two strands.

The number of different colored sleevings to use depends upon the number of single coils per winding unit, and in every case where there is more than one single coil wound into a unit, different colors should be used while winding the coils. Care must be taken to make sure that the same color is put on the start and finishing leads of each individual single coil. This is done by putting on an even number of sleevings (as 2, 4, or 6 at one time) over the wire making up the single coil. The use of colored sleeving while winding the coils saves the armature winder the trouble of lighting out and pairing up the leads.

The sleeving should be fastened with glue at a point approximately ⅛ in. into the slot section. This prevents the sleeving from slipping up and making a ragged looking job.

Fig. 2 shows a flat mush coil (M-7) that is taped all around. This coil is used for open-slot machines.

Fig. 3 shows a flat mush coil (M-8) that has only the ends taped; that is, the parts not embedded in the slots. The sleevings and leads are fastened with this tape. This type of coil is used in partly-closed-slot machines, or where the slots are deep and narrow. In case the untaped sections were easy to fan out, if the sides are taped, the wires would tend to bunch up, making a semi-round or square coil section which would necessitate the winder flattening the coil sides with pliers, which is likely to cause short-circuits.

Table I and Figs. 1, 2 and 3 cover flat mush coils of the two-layer diamond shape as used in direct-current armatures.

The coil shown in Fig. 2, type M-7, should be used whenever possible, as it can be finished complete when wound. The type M-6, Fig. 1, requires the armature winder to tape the end after the sides are threaded into the armature slots. Type M-8 requires care both in the taping and also in placing the coils in the armature.

Flat Mush Coils Used in A.C. Stators.—We will next consider the flat diamond, mush-shaped coil as used in two layer a.c. windings. This

Table I—Flat Mush Coils for Direct-Current Armatures
(See Figs. 1 to 3)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
M-6	1	Untaped	Wind mush. Tie with two or four cords. Bring leads out at ends of slot section. Use colored sleeving.	Make mold, wind and sleeve.
M-7	2	Taped	Same as M-6 except apply one layer of 0.0045-in. cotton tape half overlapped all around. Apply tape tight.	Make mold, wind, sleeve and tape.
M-8	3	Ends Taped	Same as M-6 except ends only are taped using 0.0045-in. cotton tape extending ¼ in. on slot section and catching sleeving under tape. Apply tape tight.	Make mold, wind, sleeve and tape.

type of coil is cheaper to make than a mush pulled coil, for when it is wound it is ready for the armature winder, whereas the pulled coil requires the making of puller blocks and calls for extra handling and additional labor for pulling the coils to shape. But, on the other hand, if the flat diamond mush coil contains a large number of turns of a large size wire, it becomes hard for the armature winder to shape the coils and there is considerable danger of short-circuits. As a rule, any coil using wire larger than No. 15 and having a cross-section greater than ½ in. square should be made mush puller. There will be exceptions to this rule of course, but this will eliminate the stiff coils or hard-shaping ones.

Fig. 4 shows the plain flat diamond mush (M-1) coil. This coil is wound with single-cotton-covered and enameled wire; both leads are taped or sleeved while winding and the coil is tied in four places with the leads left loose, that is, not tied to the coil. This is the simplest coil to make, but the loose leads give the armature winder trouble and a high priced man is slowed up.

The next coil type, Fig. 5, is the basket coil (M-2). This is used in the basket type of one-coil-per-slot winding. The leads of this coil are sleeved and the coil is fastened on the ends only with two turns of ¾-in. friction tape. Note that the leads are brought out on the long cell side or bottom of the coil. The long cell in this type is the bottom cell, as it has to be bent down against the stator rim to allow the top sections to pass.

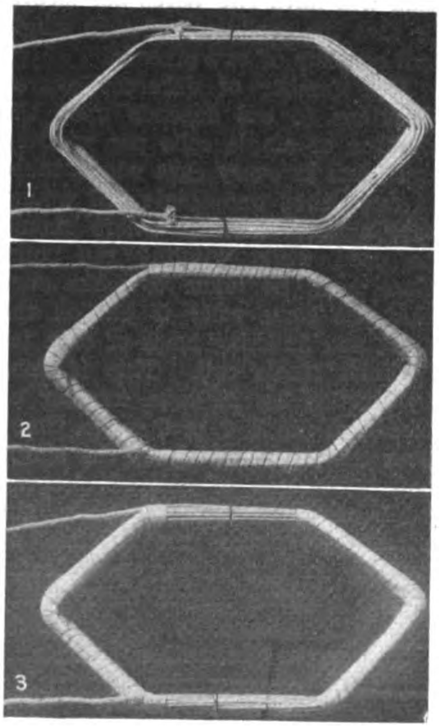
Construction of flat mush coils for direct-current armatures — See Table I.

Fig. 1—Flat mush coil (M-6) with the leads brought out from the end of each slot section. Fig. 2—Flat mush coil (M-7) taped all around for open-slot machines. Fig. 3—Flat mush coil (M-8) with the ends taped, showing method of fastening down the sleeving and leads.

The M-3 coil, Fig. 6, is the same as the M-1 flat diamond mush, except that the leads are tied to the body of the coil with a band of double-strand, fine linen thread about 1/16 in. in diameter. Two turns are taken around each lead and one or two turns around the diamond loop. This takes very little time and results in a better coil; also, it saves the winder time in winding and connecting the stator.

The M-4 coil, Fig. 7, has the front diamond point taped with one layer of .007-in. x ¾-in. cotton tape half-lapped and the leads tied after taping. This is a good construction to use for machines that operate on 440 or 550 volts in dirty places, when the coil ends are not taped after they are in place in the stator.

The M-5 coil, which is the same as the one shown in Fig. 18, is a flat mush coil with the ends partly taped. The tape is started on the bottom slot section of the coil and extended along the slot portion a distance that will bring the end of the tape ⅛ to ⅜ in. under the winding cell on both ends. The bottom end and diamond points are taped and the taping is stopped at a distance two-thirds of the total length of the top coil ends. With this type of coil, the winder does very little taping, the section left uninsulated being the only part taped by the winder.



Flat Mush Coils for Bipolar D.C. Armatures.—We will next consider the flat mush coils for two-pole, direct-current armatures. These are commonly called bipolar motors, and this is the reason for using the symbol "Bip." The armatures for these motors generally use the staggered or in-and-out type of winding.

Fig. 9 shows the Bip-1 coil, which has both the leads brought out on the end near the top slot section. This coil is of the long-pitch type with one slot section longer than the other, the long side being the top half. The leads should be brought out approximately ½ in. from the top cell and spaced approximately ¼ in. apart.

Fig. 10 shows the Bip-2 coil, which is used on armatures that have deep and narrow slots. In most cases it is easier to wind the armature if the slot portion of the coils is left untaped. The ends only are taped with sufficient insulation placed in the slot. When possible the tape should extend around the corners and onto the slot section at the leads ¼ in., but in some cases it will be found necessary to stop the tape on the ends on a line with the inside edge of the slot section of the coil.

Fig. 11 shows the Bip-3 coil, which is taped all around. The leads should be well fastened with two turns of tape and the ends of the sleeving glued and caught under the tape.

Fig. 12 shows the Bip-4 coil. This is similar to the Bip-1, except that it has a narrow pitch and half-round ends. This shape of coil is more expensive than the Bip-1 as it requires more work in making the mold and also requires more labor on the part of the armature winder to shape each coil.

Fig. 13 shows the Bip-5 coil. This is the same as the Bip-4 with tape applied all around and the leads brought out at the slot section. The coil shown is for a low-voltage armature and the leads are not sleeved, as the lead space is usually limited.

Fig. 14 shows a special coil, the Bip-6. This is similar to the Bip-3 except that the leads are brought

out at the end of each slot section. While this coil is shown with the bipolar coils and is of the same shape, it is used principally on small, four-pole, wave-wound armatures.

Mush Pulled Coils for A.C. Machines (See Table IV).—As already mentioned, these coils are more expensive than the flat mush coils. The size of wire, number of turns and total cross-section of the coil and the slot proportions are the deciding factors in determining whether to make the coils flat or pulled. The winder's time to shape the flat coil and also the amount of pounding or shaping necessary should be given careful thought as two or three hours saved in making the coils may mean four to six hours lost in winding. Deep, narrow slots require a mush pulled coil.

Fig. 15 shows the plain mush pulled coil, M-P-1. Both leads are taped or sleeved while winding, all wires in hand being placed in the same sleeve or tape. The coil is tied in four places with a strong cord. The coils are next pulled to shape by hand or in a pulling or spreading machine and the leads bent as shown, but not tied. This makes the cheapest mush puller coil, and it is satisfactory when the coil ends have to be taped by the winder.

Fig. 16 shows the M-P-2 coil. This is similar to the M-P-1 except that when pulling it, the leads and the front diamond are tied with a few turns of light linen or flax. This coil is used when the ends are not taped, as the tying secures the leads and strengthens the front end of the coil.

Fig. 17 shows the M-P-3 coil. This is similar to the M-P-1 except that the diamond points are taped and the leads tied with two or three turns of strong cord. This coil has the diamond points well protected and

Table II—Flat Mush Coils for Alternating-Current Stators

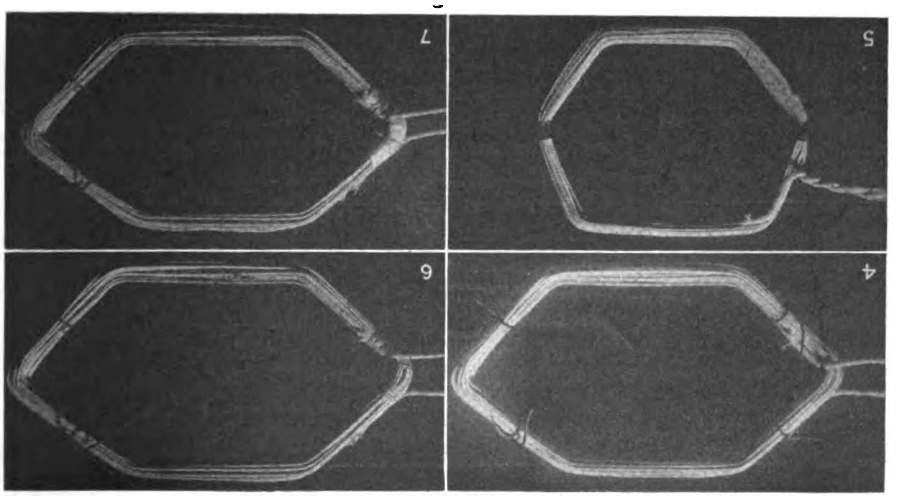
(See Figs. 4 to 8)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
M-1	4	Plain	Wind and tape or sleeve both leads. Tie with four cords.	Make mold and wind.
M-2	5	Basket	Wind, sleeve leads and tie with friction tape.	Make mold and wind.
M-3	6	Tied	Same as M-1 except leads are tied with two strands of linen thread.	Make mold, wind and tie.
M-4	7	Taped and tied	Same as M-1 except front diamond point is taped ¾-in. each side with 0.007-in. tape and leads tied with two or three turns of cord.	Make mold, wind, tape and tie.
M-5	8 Same as Fig. 18	Ends taped	Same as M-1 except ends are taped with 0.0045-in. tape half lapped. Use ¼-in. on the bottom cell section ending ¾ the length of the diamond end on top part of coil.	Make mold, wind and tape.

is used in the stator without any additional insulation on the ends except reinforcement for the phase coils. When wound stators are allowed to stand around as spares without end bells or rotors, or in some dirty place, the M-P-3 is the best coil to use.

Fig 18 shows the M-P-4 coil with the ends taped. This is the same as the M-5 (Table II) except that the M-P-4 is pulled. When taping the M-5 or M-P-4 coil, care should be taken to start the tape on the bottom or short cell for both rotor and stator coils.

Details of how to wind a small stator using the M and M-P coils are given in Chapter 21 of "Rewinding Small Motors" by Braymer and Roe, published by the McGraw-Hill Book Company.



Construction of flat mush coils for alternating-current windings—See Table II.

Fig. 4—Plain, flat diamond mush coil (M-1) showing method of tying in four places, with leads left loose. Fig. 5—Basket coil for one-coil-per-slot winding. Note how the coil is tied at the ends and the leads twisted to hold them in place. Fig. 6—This coil (M-3) is the same as M-1 except that the leads are tied to the body of the coil, which saves time for the winder. Fig. 7—Mush coil (M-4) with front diamond point taped for use in machines in which the coil ends are not taped after being placed in the stator. Coil M-5 is the same as the one shown in Fig. 18 except that it is not pulled.

Much Pulled Coils for D.C. Armature (See Table V).—Fig. 19 shows the M-P-5 coil, which is the same as the M-6. Fig. 20 shows the M-P-6 coil, which corresponds to the M-7 in Fig. 2, and the M-P-7 coil in Fig. 21 compares with the M-8 with the exception that the M-P coils are pulled to shape.

Coils *A* and *B* in Fig. 22 show a pulled type of coil used on bipolar armatures. This coil is first wound on a shuttle to the shape shown in Fig. 22*A*. The coils are then taped and dipped in a plastic varnish. The coil is pulled to shape as follows: One side of the coil is placed in a block that is cut the length of the straight part required for the bottom slot section of the coil. An equal amount of the coil projects on each side of this block, as shown in Fig. 23*A*. The cell block is fixed by holding it in a vise. Next, both ends are pulled straight down until the top half of the coil is approximately ¼ in. above the bottom cell block. This is shown in Fig. 23*B*. Next, a cell block is put around the top half of the coil and this part pulled out to the proper pitch. The coil then takes the shape shown in Fig. 22*B*.

This type of coil is expensive to make in lots of one set, as a special shuttle having large pins is required. This can be made from a piece of fiber cut to the shape of the coil in Fig. 22*A*. Also, an extra shaping operation is required as shown in Figs. 23*A* and *B*. The reason for this is that the coils are wound with a large size of wire in layers. The coil in Fig. 23 has approximately four turns of two No. 11 d.c.c. wires, which would be hard for the winder to shape if flat wound. This coil could be changed to the flat Bip-3 type shown in Fig. 11 by using four wires in hand of a smaller size of single-cotton and enameled wire

Table III—Mush Coils for Bipolar Direct-Current Machines

(See Figs. 9 to 14)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
Bip-1	9	Untaped	Wind using colored sleeving. Bring out leads on ends at top cell.	Make mold and wind.
Bip-2	10	Ends taped	Same as Bip-1 except tape ends with 0.004-in. cotton tape tight. Catch leads and sleeving, first lead ½ in. from top cell. Leave ¼ in. between start and finish leads. Tape to extend ¼ in. into slot sections.	Make mold, wind and tape.
Bip-3	11	All taped	Same as Bip-2 except slot sections are taped.	Make mold, wind and tape.
Bip-4	12	Untaped	Same as Bip-1 except narrow pitch and round ends with leads at end of each slot section.	Make mold and wind.
Bip-5	13	All taped	Same as Bip-4 except tape with 0.004-in. cotton tape tight. Catch leads and sleeving under tape and bring out leads at end of slot sections.	Make mold, wind and tape.
Bip-6	14	Taped	Same as Bip-3 except one long and one short cell lead at end of slot sections. Coil wide pitch.	Make mold, wind and tape.

and would make a more pliable coil and a cheaper coil that will not waste the winder's time. Also note that the leads in Fig. 22 are brought out at the center of the coil. This could be changed to the method shown in Fig. 11, as the leads would be out of the way while winding, but there might be a few cases where the front end room would be scant. In that case the leads would have to be brought out as in Fig. 22.

Winding Groups of Coils Without Cutting the Wire.—The present trend is toward winding mush coils for a.c. machines on a gang mold, or winding a complete pole-phase group before cutting the wire. This eliminates a number of soldered connections and also reduces the connecting time, since fewer stubs have to be taped and there are fewer leads to skin.

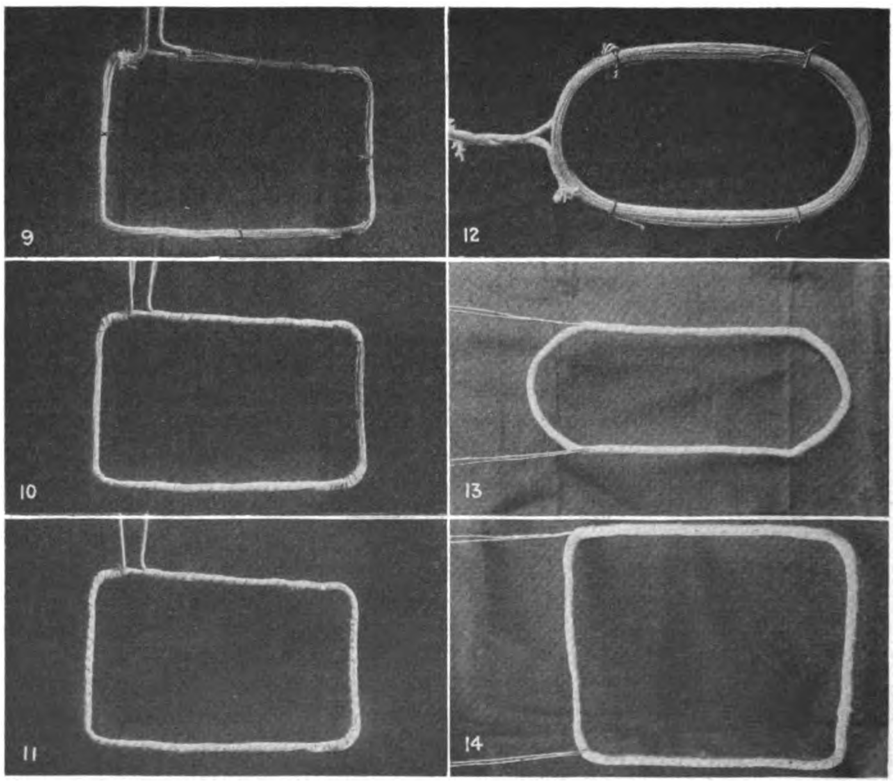
The shape of the coil does not hinder its being made on a gang mold since flat diamond mush, mush puller and concentric chain coils are being made in this manner.

Fig. 24 shows a pole-phase group of coils wound on a gang mold for a large, single-phase stator. There are six coils in this group all of different sizes, the outside or largest coil having fewer turns as the groups overlap in the stator. Notice how the wire is carried from the inside coil to the next size adjacent coil, or the finish of the first or inside coil is carried up and to the left to start the second coil. In the group shown five soldered joints have been eliminated. These coils are wound with four wires in parallel, using single-cotton and enameled wire. The gang mold eliminates the skinning and cleaning of 40 wires for each pole-phase group, which is quite an item as enameled wire is hard to scrape clean for good soldering. Note that the starting and finishing leads of the group are left long enough so that they can be used for jumpers to connect the pole-phase groups together.

The concentric type of winding having more than one size of coil per group is the ideal one for gang mold windings, regardless of whether one set of coils or more is to be wound. A number of different sized center blocks must be made in any case; therefore, it will cost very little more to make the spacing washers used between coils on the gang mold.

In the case of flat diamond mush coils, there is very little to be gained by using the gang mold idea for one set of coils unless it happens to be for a popular type and size of motor that might repeat on different repair orders. However, if the repair shop is located in an industrial plant, it might be a good investment to make a good gang mold, give it a number and include it in the motor record card for future use.

The gang mold is also used for mush pulled coils, the shuttle being arranged for winding a full pole-phase group. There is a limit to the number of coils that can be made as a unit of the mush puller type. This depends on the number of turns in each coil, the size and number of wires in hand and the number of coils per group. The restriction in this case is in the pulling, not in the winding, for in the pulling operation, a



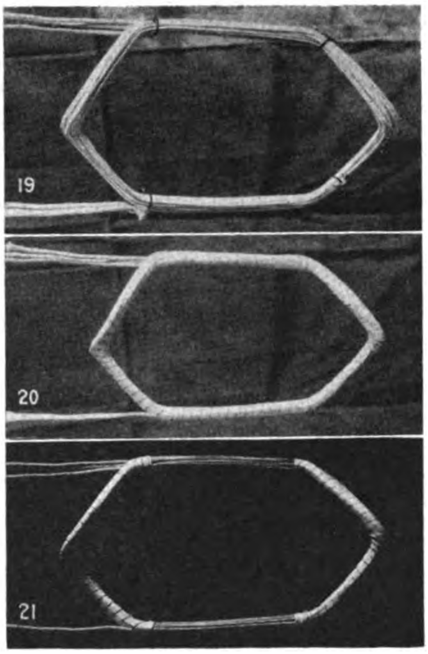
Mush coils for bipolar, direct-current armatures—See Table III.

Fig. 9—Mush coil (Bip-1) with leads brought out on the end near the top slot section. This is a long-pitch coil with one slot side longer than the other. Fig. 10—This coil (Bip-2) is used on armatures that have deep narrow slots. The slot sides are not taped, but the ends are. Fig. 11—This coil (Bip-3) is taped all around and the leads are well fastened with tape. Fig. 12—Mush coil (Bip-4) similar to Bip-1 except for the narrow pitch and half round ends. Fig. 13—This coil (Bip-5) is similar to Bip-4 except that it is taped all around and the leads are brought out at the slot section. This coil is for low-voltage armatures. Fig. 14—This is a special coil (Bip-6) similar to Bip-3 except that the leads are brought out at the end of the slot sections. This coil is used mostly for four-pole, wave-wound armatures.

Table V—Mush Puller Coils for Direct-Current Armatures

(See Figs. 19 to 21)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
M-P-5	19	Plain	Wind on shuttle using single cotton covered and enamel wire. Sleeve while winding using colored sleeving. Tie in four places. Pull and bring out leads at end of slot sections.	Make shuttle and blocks, wind and pull.
M-P-6	20	Taped	Same as M-P-5 except taped all around with 0.007-in. or 0.004-in. cotton tape, semi-tight. Catch leads.	Make shuttle and blocks, wind, pull and tape.
M-P-7	21	Ends Taped	Same as M-P-5 except ends only are taped. Catch leads and extend tape $\frac{1}{4}$ in. into slot sections.	Make shuttle and blocks, wind, pull and tape.



Mush pulled coils for d.c. armatures—See Table V.

Fig. 19—This coil (M-P-5) is the same as M-6 in Fig. 1, except that it is pulled and tied differently. Fig. 20—This coil M-P-6 corresponds with coil M-7 in Fig. 2 and is used in open-slot armatures. Coil M-P-7, Fig. 21, corresponds with coil M-8 of Fig. 3.

large mass of wire is hard to handle; that is to hold and pull out and still hold in shape.

Winding of Mush Coils.—With the flat mush type of coil for d c. armatures (Fig. 1) the coil should be started on the short cell or bottom cell side. This will allow the armature winder to put his leads on the bottom and make a better job. The finishing lead can be arranged to be on top, as in Fig. 1, which shows the starting lead brought out in this manner, and Figs. 2 and 3, which show the finished coil.

With the flat mush coils, enough tension should be used while winding the coils to make them firm, and on medium-sized coils, four cords will be sufficient to hold the coil. When placed as in Fig. 4 they are out of the armature winder's way and the two top cords can be pushed up towards the front diamond point, helping to hold the leads, and can be left on if the coil ends are not taped. The two rear cords can be cut off by the winder after the coil is in place.

With the Bip type of coil four cords are also used, spaced 90 deg. apart, at the center of both slot sections and at the center of both ends, as shown in Fig. 9.

The basket type of coil, Fig. 5, requires only two pieces of friction tape placed as shown. The leads should be sleeved or taped while winding. Sleeving is the quickest to use and for all a.c. mush coils a quantity of No. 3 white (.08-in. inside diameter) sleeving can be cut 4 in. long and used for almost all jobs.

Note the manner of placing the sleeving, as shown in the photographs of the various types of coils. As a general rule the sleeving on a.c. coils should extend at least 1 in. inside the coil, and for d.c. coils $\frac{1}{8}$ in. to $\frac{1}{4}$ in. into the slot sections, except in the Bip type. The method of placing the sleeving on this type is shown in Fig. 9.

In Fig. 5 note the manner in which the sleeving is extended past the corner into the long cell section approximately $\frac{1}{2}$ in., and also past the top point. Above all, keep all types of mush coils free from crosses in the slot section and feed the wire from one side of the mold to the other slowly and smoothly, particularly on coils that have to be threaded into the slots, since all crosses must be worked out of the slot sections by the armature winder as he threads the wires in. This not only slows him up but, what is worse, it concentrates the crosses at one point at the end of the slot and if any pounding is required to shape the coil, there is danger of shorts.

Mush puller coils for a.c. stators—See Table IV.

Fig. 15—Plain mush pulled coil (M-P-1) on which the leads are taped or sleeved while winding. Fig. 16—This coil (M-P-2) is similar to M-P-1 except that the leads and front diamond are tied while the coil is being pulled. Fig. 17—This coil (M-P-3) is the same as M-P-1 except that the diamond points are taped and the leads tied. Fig. 18—Coil M-P-4 shown here is the same as coil M-5 in Table II, except that it is pulled.

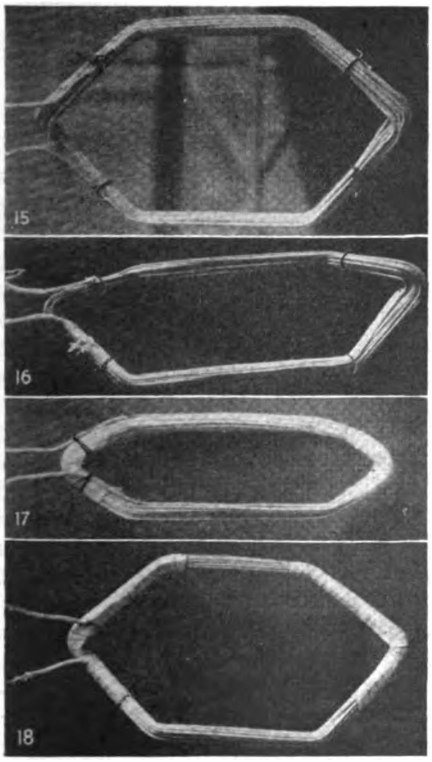


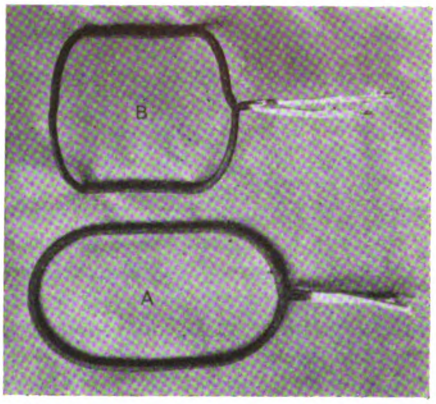
Table IV—Mush Puller Coils for Alternating-Current Stators

(See Figs. 15 to 18)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
M-P-1	15	Plain	Wind on shuttle with single-cotton-covered and enameled wire. Tape or sleeve leads and tie in four places while winding. Bring out leads at diamond point. Pull to shape.	Make shuttle and puller blocks, wind and pull.
M-P-2	16	Tied	Same as M-P-1 except leads are tied with a thin flax or linen thread while pulling.	Make shuttle and blocks, wind, pull and tie leads.
M-P-3	17	Ends taped and leads tied	ame as M-P-1 except that lead end diamond point is taped with 0.004-in. cotton tape $\frac{3}{4}$-in. either side of loop and leads tied with two or three turns of cord.	Make shuttle and blocks, wind, pull, tape and tie.
M-P-4	18	Ends taped	Same as M-P-1 except both ends are taped with 0.007-in. cotton tape, starting $\frac{1}{8}$-in. to $\frac{1}{4}$-in. on bottom slot section and finishing on top end $\frac{1}{3}$ the distance from top cell to front loop.	Make shuttle and blocks, wind, pull and tape.

When winding any type of mush coil with tension on the wire, it will be noticed that there is a considerable bulge on the straight parts. Do not pound this bulge out while winding, as it helps to relieve the tension at the corners after the coil is in place on the machine after taping or after pulling.

The above point can best be illustrated with the mush pulled coil. Fig. 25 shows a mush puller coil just off the shuttle. Note the bulge in the center of the coil between the cord bands and also note how tight the ends are around the pins. This is shown also in Fig. 26, which is a close-up view of the lead end of the coil in Fig. 25. This photograph shows how the wires spread out as they get past the tie cords towards the center of the coil. Then Fig. 27



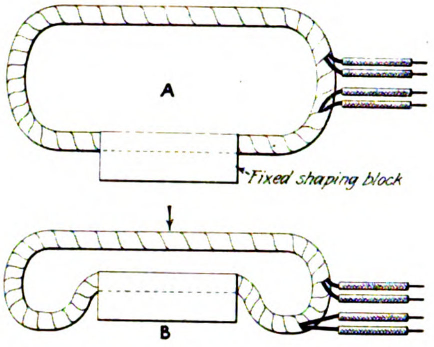
Figs. 22 A and B—These are pulled types of coils for bipolar armatures. The coil is wound and taped as shown in A. It is then pulled to the proper shape, as in B.

shows the same end as shown in Fig. 25 after the coil has been pulled to shape. Note how the wires around the pin have loosened up and spread apart.

The reason for this is that, when pulling, the blocks used to hold the slot sections are a tight fit, thus forcing the wires together and pressing the slack out to the ends. With taped coils the tape forces the slack out on the ends. With untaped coils the forcing of the wires in the slot also chases the slack out to the ends. Therefore, the bulge is helpful and should not be pounded or ironed out in any way while winding mush coils.

In Figs. 26 and 27 tape should be applied to the leads of a.c. coils, a thin (.0045-in.x¾-in.) tape being used, edge-lapped.

Taping of Mush Coils.—There is quite a knack in applying the finish



Figs. 23 A and B—These diagrams show the extra shaping required in making the coil shown in Fig. 22.

tape to all types of mush coils. The tape must be applied semi-tight; that is, tight enough so that it will not slide nor appear baggy, and then again it must not be too tight or all the slack in the wire will be forced ahead of the tape with the result that at the end of the taping operation when near the starting point, the wires will bulge out. It will then be found impossible to pull these bulging wires into the same size as the rest of the coil without twisting and crossing the wires, which is not only troublesome, but is likely to damage the insulation.

Another reason for semi-tight tape is that the majority of mush coils require considerable shaping while winding the armature. In the slot sections it is necessary in some cases to flatten the coil sides with a pair of pliers. Therefore if the wires are held tight by the tape, any attempt to shape the coil would tend to chafe the insulation on the wires and thus cause short-circuits.

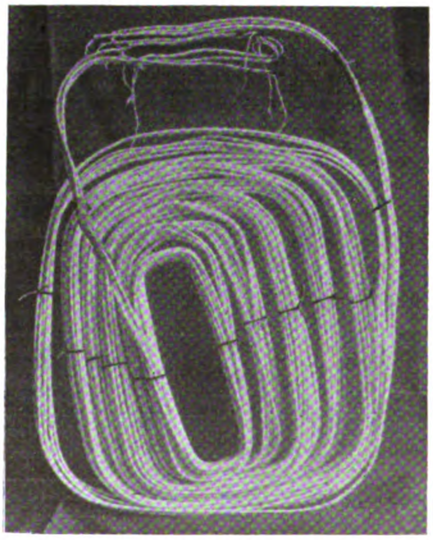
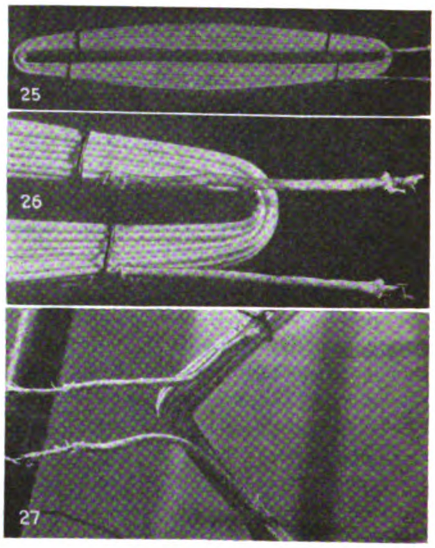


Fig. 24 — Complete pole-phase group wound on gang mold without cutting the wire.
These coils are for a large, single-phase motor.

On mush coils that have only the ends taped, particular care must be taken not to pull the tape too tight, as all the slack will be forced into the slot section of the coil and when the coil is wound into the machine the close fit of the wires in the slot section will force all the slack out to each end of the slot, creating a bulge that increases the chance for grounds or shorts.

Molds for Mush Type Coils.—The simplest mold is the one used to wind flat mush coils. It consists of three pieces: a base, a center block, and the outside plate. The base in most cases is made of 1-in. wood and the center block can be cut from fiber up to ¼ in. thick, and above



Three views of a mush puller coil.
Fig. 25—Note how tight the ends are, and the bulge in the sides between the cord bands. An enlarged view of the end of this same coil is shown in Fig. 26. In Fig. 27 the same coil end is shown again after being pulled, illustrating how the wires at the end have loosened up and spread apart.

¼ in., from wood. The outside plate is also made from wood. One thing to watch is to have all surfaces level and when fastening the center block to the base, be sure that all corners fit down tightly against the base. Otherwise, the wires will pull down between the center block and the base or front plate.

To make it easy to remove coils after winding, the two corners close together on the center block should be tapered slightly, the low side being toward the outside plate. If this is done the coils can be slipped off without difficulty.

Coil shuttles will be described in a later article. Some types of flat mush coil molds are shown in "Rewinding Small Motors," by Braymer and Roe, already referred to.

1927

This is a New Year and you are going to do bigger and better things in new and more resourceful ways. Here is a suggestion that will benefit you and others who are working with you, without your knowing it.

AS TIME is recorded, we are at the beginning of another twelve-month period and the things we do and the results we accomplish in 1927 will be compared according to custom with the best of the results for a similar period already passed through. As all of us accumulate knowledge and experience, we should be able not only to secure better results from routine work year by year, but be able to assume larger and more difficult responsibilities. To learn to do one or two things better and better as time goes on is an index to progress, but to those with ambition and initiative this is not enough. Ambition that carries with it vision, and initiative that carries with it confidence born of experience, force us ahead to explore new fields of operation and new ways to make hard jobs easy for the worker and less expensive for the employer who pays his wage.

Every operator who has been engaged in practical work for ten or fifteen years and elevated himself to a position of responsibility can look back and put his finger on several things that helped him forge ahead to a better position and an advance in salary. And in this review of the past he can recall, not one, but dozens of times when a little help on a tough problem would have prevented mistakes and perhaps speeded up the progress that was made.

Not long ago I heard an operator define an "expert" as an ordinary man away from home. This definition is a little deep, but if you think a bit you can probably recall conversations with such experts in which the big "I" and little "you" formed the main thread of the discourse. Such bragging these days does not come from men who do things worth while, simply because their work and their results do not need the advertising of the braggart. There is, however, one effective way to record the results of hard work and advanced thinking on operating problems: namely, by writing articles for publication in journals like INDUSTRIAL ENGINEER, read by operators in far-flung kinds and sizes of plants.

AT THE beginning of this New Year, my message to all operators is to read more and compare their results and ways of doing things with those of other operators in other kinds of plants. Then determine to write at least one general article during the year on some problem you have spent a lot of time on. Give details of how the problem came·up—the conditions and equipment involved, what you set out to do and just what you did step by step in working it out, with all the changes, revisions and mistakes made, together with the results that were finally accomplished. Such an article will mean a lot to you for it will furnish a record of your way of handling a troublesome job. But it will mean a lot also to others who may be in the midst of just such a problem and have secured results by another method. Such an article will inspire others to write similar articles and by the end of 1927 you will get back through these articles more than you have given, if you apply and profit by the information thus secured. After all it's helpful co-operation these days that solves the big problems—not bragging about your single-handed part in their solution, as the expert who is an ordinary man away from home, sometimes does.

By the way, the February issue of INDUSTRIAL ENGINEER will contain just such articles as I have referred to, for it will be a special number in which operators will give details of the things they have accomplished during 1926. Read all of these articles and then if you can give some experiences or ways you have accomplished similar or better results, I know that the editors of this publication will be glad to hear from you, if it is no more than a letter indicating that you have read the articles in the February number and plan to write something later.

Let's get better acquainted during 1927 right from the start. Those who have written me, and there are hundreds of you now on my list, write again and again. Those who have not written—well make the February issue an excuse and I'll promise to make it easy for you to write often afterward. Will you do that?

Practical Pete

P.S. *Don't forget the prizes offered on this page in the December issue. You have done something, probably many things, worth while during the past year. Put the facts on paper: if you are busy never mind the English or the grammar. The prizes are for facts, not culture, and the facts told in your own way will get just as much consideration as though they were written by a college professor. Just write and tell what you have done, how you did it, and what you accomplished thereby.*

P. P.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Editor*

We Wish You Happiness and Success in the New Year

IN THE rush of the day's work, with its problems and triumphs, vexations and joys, there is oftentimes little opportunity to pay much attention to the other fellow or concern ourselves as to how he is faring: to extend a helping hand or thank him for service that he may have been able to render us. However, the passing of the old year affords a convenient moment for pausing to recall with pleasure and gratitude those with whom we work and to whom we are indebted, and wish them well.

The Editors take this opportunity to thank the readers of INDUSTRIAL ENGINEER for their co-operation and support, in the many ways in which these have been shown during the past year, and to extend every good wish for a New Year filled with Health, Prosperity and Happiness.

Where Does Your Plant Stand in Regard to the Power Question?

SECRETARY HOOVER, in his annual report to the Department of Commerce, states that during the period covered by the report there has been an increase in power consumption of between five and six million horsepower in mills and factories. During this period there has been comparatively little increase in the number of boilers and engines installed in these plants; in other words the increased power consumption is accounted for by the operation of electric motors on purchased power. Mr. Hoover further states that there has been a change from the use of direct-connected steam-engine-driven equipment in mills and factories to the generation of electric power for distribution throughout the plant, so that at the present time 70 per cent of all factory-generated power is delivered to the machines electrically.

This report emphasizes two trends which have been many times pointed out and advocated by INDUSTRIAL ENGINEER: namely, the electrification of steam-engine-driven mills and the increased use of purchased power in mills and factories. Electrification of all steam-engine-driven mills is a foregone conclusion and it is only a matter of time before it will be completely accomplished. The use of purchased power in place of factory-generated electric power is still the subject of argument in many plants. At the present time it is becoming standard practice to use purchased power, except in locations where power cannot be purchased from utilities generating it in large quantities, or where there are waste products from factory production, such as blast furnace gas, coke breeze, lumber waste, and the like, which can be utilized only at the point of production, or in cases where low-pressure steam is required for process work in the factory.

Where does your plant stand in regard to these trends of the day? Is it hesitating and lagging behind, or is it abreast of the times? Power cost often forms a good share of the cost of production; hence frequent check-ups on the cost of power at your plant can certainly not be called a waste of time.

Let Good Judgment Govern Procedure When Experience Is Lacking

THE often-heard saying, "If a little bit is good, more is better," doubtless has a certain amount of truth in it, and probably most of us apply it to a greater extent than we realize. It is not difficult, however, to cite many instances where this saying does not hold true.

One such instance is in the application of belt dressings. Altogether too often belt dressings and preparations of one sort or another are applied so frequently and liberally to leather belts that their efficiency and even their life may be seriously affected. The proper use of a good, prepared dressing will do a great deal towards keeping a belt soft and pliable, and preventing slipping and cracking. The application of surface dressings in amounts sufficient to build up a heavy coating is not only a waste of money, but a definite, and common, form of abuse. Using too much belt dressing is just about as bad, and perhaps worse, than not using any.

Lubrication of bearings is another instance of where too much of even a good thing may be harmful. In many cases the bearings on motors and other equipment are provided with gages that show the oil level, and are put there for the purpose of making it easier to lubricate the bearing properly. Oil or grease are absolutely essential to the operation of all except a few special types of bearings, but to fill a bearing full of oil, regardless of the manufacturer's recommendations, is simply inviting trouble. The excess oil usually flows out and may cause a great deal of trouble, as when it gets on motor windings, for instance.

Erroneous practices and notions regarding the operation and care of equipment are not difficult to find, and are mostly due to ignorance or lack of experience. In addition, every operating engineer is frequently confronted with puzzling problems and situations. In all such cases, a liberal application of the quality of mind known as "plain horse-sense," will do much to prevent mistakes that may easily be explained, but should nevertheless not be made. In few callings is there greater need for plenty of "horse-sense" than in operating and maintenance work. The operator who has it and uses it will find that it will save him from many an embarrassing situation.

Measure the Value of Your Equipment in Terms of the Service It Renders

AT THE beginning of a new year most organizations take stock of their assets and possessions to find out where they stand in a business way. In an industrial plant every piece of equipment is duly recorded, depreciation is calculated, and when all of the figures have been added up and the totals put down the job is considered to be finished. The figures obtained in this way ostensibly show the physical value of the plant, and can be used for a variety of business purposes.

An inventory of this character is both necessary and useful, but from the maintenance and operating standpoints it may fall far short of presenting vital information regarding the physical conditions, operating efficiency and so on of the equipment. During the past few years great strides have been made in the design and construction of almost every type of equipment. Something new is coming along nearly every day. The unusual or unheard-of five or ten years ago is the commonplace of today—and most of the equipment and many of the methods used today will be obsolete five or ten years from now. Wherefore, it comes about that a piece of equipment may be obsolete long before it actually wears out, assuming that it is given anything like proper maintenance attention.

Take the time some day to study a few of the important items of equipment in your plant and appraise them on the basis of their worth and efficiency as compared with the money-saving service that can be obtained from the latest designs now available. Unless the plant has been in operation for only a comparatively short time, or has recently been re-equipped, it will not be surprising if many items almost automatically list themselves as liabilities rather than assets.

Apply Electrical Power Instead of Manpower for Handling Materials

CLOSE competition between industrial concerns make reductions in manufacturing costs of utmost importance. To alert operating men who are on the lookout for opportunities to suggest money-saving ideas, we suggest that one of the most fertile fields for making cost reductions is in the methods of handling material. These are receiving more attention today than ever before because of a decreasing wage differential between the so-called unskilled or common laborer and the semi-skilled worker. Also, due to the immigration restrictions, the former surplus in the supply of common labor no longer exists. This condition has been felt most in the increased cost of the labor for material handling.

Big opportunities are ahead for those who use power-driven equipment for the transportation of material, and many industrial plants are taking advantage of them. For example, in actual installations one storage-battery truck or tractor has replaced from two to thirty-five men in different industries and types of service. An average saving per unit of truck installed is estimated as approximately five men. The installation of conveyors, hoists, tiering machines, hand-lift trucks, and other equipment of this character has also shown worthwhile savings.

How much equipment will the annual wages of five men buy, maintain and operate? What will its installation mean in the reduction of overhead and other costs? These are questions which every operating man should ask and seek until he finds the answer. He will then have the facts on which he can talk dollars-and-cents, which is the best language to use when persuading the management that it is sound economy to purchase equipment that will more than pay its cost by the savings it makes in the payroll.

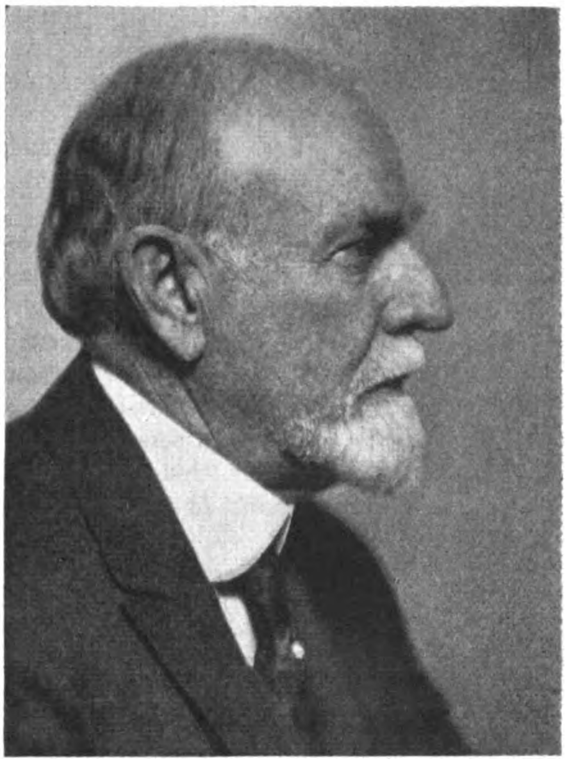
"Put It in and Forget It" May Be Taken Too Literally

FREQUENTLY an equipment salesman clinches his arguments on the dependability of his products by boasting, "After you put this in, you can forget about it." Such statements sound convincing and may be true, *if* the equipment is serviced properly. There is practically nothing about an industrial plant that does not require some attention either at short or long intervals. Bearings, for example, are often intended to be oiled only at long intervals and "forgetten" the remainder of the time.

Servicing of fire-fighting equipment in particular should not be forgotten, although it is one class which is often neglected. Many of the portable extinguishers will corrode so that they will not discharge, if left too long without emptying and refilling. Also, a unit may be discharged and, if left empty, may cause a serious loss. Even though the equipment is in perfect condition, it may be hidden or access blocked by a temporary condition or poor housekeeping. Particular attention should be given to the possibility of freezing (some extinguisher solutions freeze—others do not) when kept in exposed locations, such as unheated warehouses or storerooms.

Safeguards, also must not be forgotten. Otherwise, they may be removed, or be rendered inoperative, or not function properly because of neglect to make the necessary adjustments. Safety requires continuous vigilance not only toward keeping the idea before the men, but also in the provision and inspection of the safeguard.

Servicing, especially where it is necessary only at long intervals, requires that it be placed on a routine or schedule, otherwise it may be forgotten entirely. Does your maintenance department have a schedule for such inspections, or are they on a hit-or-miss (with too many cases of miss) basis? The first of the year is a very good time to establish the proper routine for such work.



JAMES H. MCGRAW

Engineering and Industry Pay Tribute to James H. McGraw

A RARE testimonial was given to a career that began at a country school teacher's desk, when more than 1,000 leaders of engineering thought and accomplishment and industrialists of note assembled in the grand ballroom of the Hotel Astor, New York, on December 17, to commemorate James H. McGraw's 41 years of service as a publisher, on the occasion of his sixty-sixth birthday. Thomas A. Edison, as honorary chairman, headed a distinguished list of those who sponsored the testimonial. These included among others, Secretary of Commerce Herbert Hoover; Gen. Guy E. Tripp, chairman of the board, Westinghouse Electric and Manufacturing Co.; Gerard Swope, president General Electric Co., and Owen D. Young, chairman of the board, General Electric Co.

John W. Lieb, vice-president and general manager of the New York Edison Co., was toastmaster. Before he called on the speakers chosen to represent various business and professional interests, Mr. Lieb sketched Mr. McGraw's career briefly, dwelling for a moment on the comprehensive nature of the McGraw-Hill publications.

Willits H. Sawyer, president of the American Electric Railway Association, was the first speaker. He told what Mr. McGraw's counsel and leadership had meant to the electric railway industry, recalling that the publisher's first journalistic venture had been in the street railway field 40 years ago. This industry, he said, in spite of temporary adversity, must and will go forward. The McGraw-Hill papers have pointed the road to constructive co-operation and co-ordination in the transportation field. He called the guest of the evening a "fountain of well-directed enthusiasm" and read a testimonial to him on behalf of the A.E.R.A.

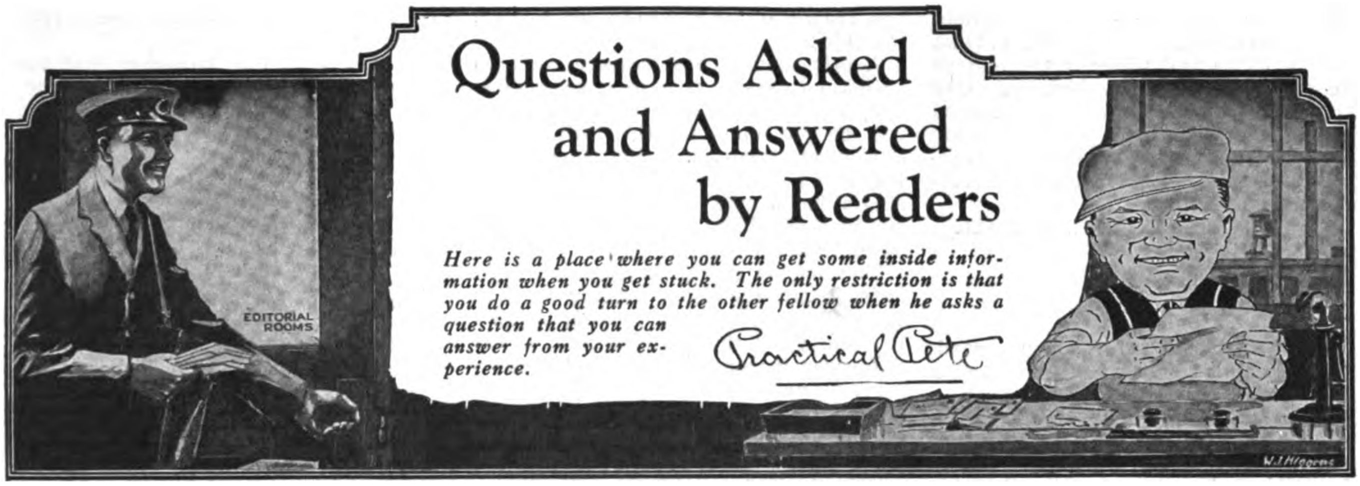
Gen. Guy E. Tripp, chairman of the board of directors of the Westinghouse Electric & Manufacturing Co., who was called on to represent the manufacturing interests, refused, in a witty speech, to "catalog" Mr. McGraw, but referred to him as a "practical philosopher." Idealism was one of the foundation stones on which the publisher had built.

Charles L. Edgar, president of the Edison Illuminating Co. of Boston, remarked that business publications might be classed as good, bad and indifferent. The McGraw-Hill papers, it was his conviction, fell into the first class. Constructive, forward-looking, they had rendered a real service to the electrical industry, and central-station interests were glad to be able to express publicly their appreciation of the leadership exercised by Mr. McGraw.

Dexter S. Kimball, dean of Sibley College, Cornell University, speaking on behalf of the engineering profession declared that the greatest guaranty of the permanency of present civilization is the printed record we are making of the experiences and processes of applied sciences. In that this civilization differs from its predecessors. And Mr. McGraw, he said, was an integral part of the picture because publication of these records was the work of the McGraw-Hill companies.

The last speaker was Edward J. Mehren, vice-president of the McGraw-Hill Publishing Company, representing the publishing industry. He outlined the business principles of Mr. McGraw which are found exemplified in his many publications. He said that an ardent spirit of service, of faith, vision, courage, and perseverance were the qualities Mr. McGraw has brought to bear on the work of his organization.

Responding, Mr. McGraw attributed any accomplishment of his to two things—capable and loyal associates and the support of the professions and industries represented at the dinner. He expressed in warm terms his gratitude to the engineers and industrialists of America and asked for their continued co-operation. When he had fought, he said, he had done so without passion. His sole objective was accomplishment, and when an objective was attained there was no room for bitterness or jealousy over the apportionment of credit. Optimism, Mr. McGraw observed, is an essential of leadership. There must be faith that sincere and earnest work will be rewarded. Edited in this spirit, industrial papers will not only be human, but vibrant with life and imbued with the ambition of high service. In his more than 41 years of work he had seen the civilized world made over. He rejoiced in the engineers and industrialists, and the marvels they had wrought. Three score and six years, he declared in conclusion, had no terrors for him. It was no time to retire but to press on to further endeavor, repaid by the fascination of work—the "joy of the job."



Who Can Answer These?

Checking the Alignment of Lineshafts.—I have always heard that in checking the alignment of a shaft, the belts should be thrown off. It seems to me that the belts should be left on the pulleys to give the approximate operating conditions. In other words, a belt may draw a pulley and shaft and its bearing to one side in operation, but if the belt is off, the shaft may appear to be in line. I believe that the alignment should be checked as nearly as possible under operating conditions. I wish some of our readers would discuss this question.
Moline, Ill. H. J. K.

* * * *

Power Factor of Transformers Feeding a Resistance Load—We have two 700-kva., single-phase, 25-cycle, 11,000/220-volt Allis Chalmers transformers with an impedance of 58 per cent that are to be connected in open delta to feed a 400-kva. annealing oven which is heated by resistors. All the impedance in each transformer will be removed down to 12 per cent, which is the limit. Will some reader please tell me what the efficiency and power factor of the transformers will be when they are operated in this manner.
Keokuk, Ia. L. M. S.

* * * *

Reducing D. C. Voltage—Current for operating our signal systems is now supplied by two motor-generator sets; the demand on the generators varies from 15 to 20 amp. at 15 to 20 volts. We wish to discard our motor-generator sets and I should like to know of some suitable method of reducing the voltage on our 110-volt, d.c. service line so that we can operate our signal systems from it. It has occurred to me that a water rheostat might be suitable for this purpose. If so, can some of the readers give me the data for such a rheostat? Can anyone suggest a better method?
Chicago, Ill. M. G.

* * * *

Size of Alternator Required for Industrial Plant.—We wish information on selecting capacity of alternators for small a.c. power plants for industrial use. (1) Recently we had to calculate the size of generator required to drive two 175-hp., 80 per cent power factor, three-phase, 60-cycle, 257-r.p.m., 440-volt, synchronous motors direct-connected to ammonia compressors, and three or four small, squirrel-cage induction motors aggregating 60 hp. The generator was required to be able to start one synchronous motor at full line voltage when the other synchronous motor was already developing full capacity. What generator capacity would be required to handle this load?

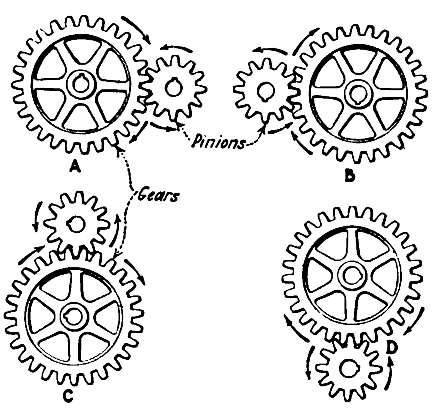
(2) Another recent case involved the electrification of a small factory. There were about ten 5-hp. motors, four 10-hp. motors and two 25-hp. motors, all squirrel-cage induction motors; the lighting load was about 5 kw. and there was one passenger elevator requiring one 7½-hp. motor. It was desired to have the three-phase, 60-cycle, 220-volt generator direct-connected to a crude oil engine. What capacity of generator would be required in this case? In arriving at the size of generator required, is it enough to add the various full-load currents of the motors and use this as the size of the generator? How do we take into consideration the power factor and the inrush current taken by the motors in starting? How can we be sure that the voltage will not drop very much so as to cause flickering in the lights when the motors are started, especially when the elevator is operating?
Lima, Peru. A. B.

* * * *

Locating Trouble in Conduit Wiring—We have an extensive system of conduit wiring in our buildings and underground, which takes care of 440-volt power and 110-volt lighting service lines. This system was installed several years ago, and since then certain changes and additions to the plant structures have rendered long sections of the conduit very inaccessible. At various times faults have occurred in the wiring which were very difficult to locate. I wish some of the readers would tell me the best methods of locating grounds and shorts, and also suggest the best ways of testing and checking the condition of the wiring, so that we can detect and locate weaknesses before they become serious.
Providence, R. I. G. F. H.

* * * *

Location of Motor Pinion.—Is there a preferred location of the motor pinion with respect to the driven gear? The accompanying diagram shows four different drive arrangements, one having the motor pinion on top of the driven gear, another with the pinion at the bottom, and others with the pinion on either



side of the gear. The direction of rotation of the gear and pinion is indicated by the arrows. Which of these locations is preferred from the standpoint of stress on the motor frame and on the foundation bolts, lubrication of gear and pinion, and ease of maintenance and inspection? Are they all equally good? I should like to have some of our readers discuss this question, and give me the benefit of any experience they may have had with such a problem.
Landgraff, W. Va. U. J. S.

Answers Received To Questions Asked

What Size of Belt Is Required for This Drive?—A 15-hp., 1,750-r.p.m. motor is used to drive a punch press. The pulley on the motor is 6 in. in diameter and the driven pulley is 40 in. in diameter, the distance between centers of the motor and press pulleys being 15 ft. I wish readers would give me some information regarding the adaptability of leather belts to this drive. Specifically, what width of leather should be used to give the best results? Should this belt be single or double-ply? Would you advise the use of some other type of belt and if so, what kind and why?
Rockford, Ill. R. W. A.

Answering R.W.A. I would say that a leather belt is quite the proper thing for this type of drive. A 4-in. heavy, single belt (16-18 oz. or 3/16 in. thick) would be perfectly satisfactory for this drive. A 5-in. medium single belt (14-16 oz. or 5/32 in. thick) would answer just as well. The choice between these two would depend upon local conditions, such as the face of the pulleys, moisture and general driving conditions.
Fort Worden, Wash. E. I. PEASE.

* * * *

I would recommend a single leather belt for R. W. A.'s punch press drive. The question does not state the width of the pulley face, or the material of which it is made. If the pulley is made of paper or similar material a 6-in. single belt will easily transmit 20 hp. at this speed. The pulleys are closer together than some authorities consider good belt practice. According to F. W. Taylor, as given in Kent's Mechanical Engineers Pocket Book, from 20 to 25 ft. is the best distance for shaft centers. He also states that a leather belt will last from 7 to 13 yr. under ideal conditions. Double belts should not be run over pulleys under 12 in. in diameter.
GRADY H. EMERSON.
Birmingham, Ala.

* * * *

Under the conditions specified in R.W.A.'s question our belt tables would call for a 3-in., light-double, first-quality leather belt. This would include due allowances for the unfavorable operating conditions involved in the high peaks in the punch press load and the undesirable pulley ratio. However, our experience with punch press drives has shown the advisability of heavily over-

belting this class of work. We would advise using a light double belt at least 5 in. in width and wider if the pulleys are wide enough to permit it. Our service records show that the increased cost of this wider belt will be quickly offset in increased production, especially if a grade of belt with high overload capacity is used.

R. R. TATNALL.

Experimental Engineer,
J. E. Rhoads & Sons,
Wilmington, Del.

* * * *

R.W.A. asks for information regarding the proper thickness and width of a belt driving a punch press from a 15-hp. motor with a driving pulley 6 in. in dia., at 1,750 r.p.m. He does not give the horsepower which is actually transmitted, but we presume that his motor is not overloaded. The accompanying table gives the horsepower that solid woven belting will transmit per inch of width in the single, double and triple thicknesses at various belt speeds. Figures given in this table are for drives where the arc of contact is about 160 deg. or over. The inquiry does not state whether the drive is horizontal, vertical or inclined. If it were a horizontal drive with an under pull, the arc of contact would be increased.

Velocity in f.p.m.	Single	Double	Triple
200	0.31	0.55	0.73
400	0.63	1.15	1.45
600	0.94	1.70	2.18
800	1.2	2.25	2.88
1,000	1.5	2.80	3.58
1,500	2.2	4.15	5.33
2,000	3.0	5.45	6.88
2,500	3.6	6.65	8.30
3,000	4.2	7.70	9.60
4,000	5.0	9.50	11.40
5,000	5.3	10.50	12.05

The belt speed is about 2,750 f.p.m. and by consulting the table we find that a double belt will transmit about 7 hp. per inch of width. However, the service mentioned requires a margin of safety, and we believe that a 4-in. double belt would be satisfactory.

CHARLES HATHAWAY.

Stanley Belting Corporation,
Chicago, Ill.

* * * *

The following suggestions may help R. W. A. in the choice of the proper belt to meet his conditions. The use of a leather belt is to be recommended, I believe, unless the location is damp or the belt is to be subjected to extremes of heat and cold. A leather belt, if well selected and properly handled should last for 20 yr., and even then, if the worn parts are cut off the remaining portion may be used for a shorter drive. In the selection of a belt the quality of the leather should be the first consideration. The leather should be firm, yet pliable, free from wrinkles on the hair or grain side, and of an even thickness throughout.

In this case, as the motor pulley is small, a single belt would be best. Where double belts are used on small pulleys, the contact on the pulley face is less perfect than it would be if a single belt were used. More work is required to bend a heavier belt as it runs over the pulley than in the case of the more pliable single belt. The centrifugal force tending to throw the belt from the pulley also increases with the thickness.

A belt should be sufficiently wide to withstand safely, and for a reasonable length of time, the greatest tension that will be put upon it; this will be the tension of the driving side when starting under load. The safe tension for single belts may be taken as 60 lb. per inch of width; single belts average $\frac{3}{16}$ in. in thickness.

The tension on the driving side, however, is not the force tending to turn the pulley. The force tending to turn the pulley, or the effective pull, is the difference in tension between the driving side and the slack side of the belt. The tension on the driving side depends on three factors: the effective pull of the belt, the co-efficient of friction between the belt and pulley, and the arc of contact of the belt on the smaller pulley.

The arc of contact may be determined approximately as follows: Measure the circumference of the small pulley. Stretch a string over the two pulleys to represent the belt. Take another string, hold one end at the beginning of the arc of contact, as shown by the string stretched around both pulleys, wrap it around the smaller pulley, and cut it off at the end of the arc of contact. The arc of contact in degrees is found by dividing the product of 360 times the length of the string representing the part of the belt in contact by the circumference of the pulley. The following table shows the effective belt pull allowable for various arcs of contact.

Arc of Contact in Degrees	Allowable Effective Pull in Lb. per Inch of Width
90	23.0
112½	27.4
120	28.8
135	31.3
150	33.8
157½	34.9
180 or over	38.1

To find the width of a single leather belt for transmitting a given horsepower, use the following rule:

$W = (33{,}000 \times hp.) \div (V \times C)$

where W = width of single belt in inches; $hp.$ = horsepower to be transmitted; V = velocity of belt in feet per minute; and, C = allowable effective pull per inch of width from the above table.

In this case the belt speed is rather high, but this is not a bad fault because the higher the speed of the belt, the less need be its width to transmit a given horsepower. The belt speed is approximately 2,750 r.p.m. $(3.1416 \times 6) = 18.85$ in. = circumference of motor pulley. $18.85 \times 1{,}750 \div 12 = 2{,}748$ f.p.m.

As it is almost as easy to find the arc of contact by the simple method of measurement as previously explained as to compute it by formulas, the following rule may be used at present for finding the width of the belt, and R. W. A. may later measure the arc of contact and substitute the values in the preceding formula. For single belts multiply the horsepower to be transmitted by 33,000 and divide the product by the speed of the belt in feet per minute multiplied by 38.1 (for 180-deg. arc of contact), thus: width = $(15 \times 33{,}000) \div (2{,}750 \times 38.1)$ = 4.75-in. belt. The nearest commercial width is 5 in.

It will be found, however, that the formula that uses the actual arc of contact as one of its values will give more accurate results. ARCHIE L. FORGER.

Chief Electrician,
G. A. Head Electric Co.
Laconia, N. H.

* * * *

Changing Speed of Direct-Current Motor—We have a General Electric, Type CO 15, form A, four-pole, compound-wound, 230-volt, 15-hp. motor, serial No. 124206. This motor is rated at 55.5 amp. and a speed of 625 r.p.m. The actual no-load speed, however, is very close to 800 r.p.m., due possibly to some repairs that have been made to the armature winding. Will some reader kindly tell me how I can decrease the speed of this motor to 550 r.p.m.? We would like to make this change in speed by some manipulation of the fields rather than rewinding the armature.

Hannibal, Mo. R. E. G.

In reply to R.E.G.'s question, it does not seem likely that he will be able to make so great a change in speed without rewinding the armature. There are several methods for reducing the speed of a d.c. motor.

If there is sufficient air gap between the armature and field poles, this may be reduced by shimming under the field pole faces, that is, between the field core and the frame. If the bearings in this motor are in good shape, the air gap may be made very small, with a gratifying reduction in speed.

Another method of reducing the speed would be to insert resistance in the armature circuit, being careful to insert it in such a place that it will not affect the field. The speed may also be varied by moving the brush yoke, but it may be shifted only as far as proper commutation will allow.

Any of these methods or a combination of all three will decrease the speed of the motor and at the same time will, of course, affect the efficiency. It seems to me that it might be well for R.E.G. to purchase a new motor of the specifications he desires providing, of course, that he can either use this motor in a different location or perhaps trade it in.

Cleveland, Ohio. G. H. WINTERSTEEN.

* * * *

In reply to R. E. G., the speed of a direct-current motor may be increased or decreased about 10 per cent by increasing or decreasing the air gap between the armature and field. If the change in speed must be accurately determined, a magnetization curve of the design of this individual machine will be necessary. As a general rule, where the change in speed is not too great, adjusting the air gap will produce the desired results with but little experimenting. There are some cases, however, where the motor is designed to work high up on the saturation curve and the iron is practically saturated, or perhaps very low down on the saturation curve and the excitation is nearly all used up in the air gap.

Reducing the air gap reduces the speed and increasing the air gap increases the speed, although decreasing the speed is usually the easier to accomplish. To reduce the speed, thin steel shims are placed next to the frame, using the same number under

each pole piece. The amount of change that can be made in this manner depends upon the length of the original air gap.

If a great enough reduction cannot be obtained in this way, a further reduction may be gained by placing resistance in series with the armature. This resistance reduces the voltage impressed upon the armature winding, as the speed of the motor is proportional to the applied voltage. This is a sure way of reducing the speed, but it is an inefficient method.

Indianapolis, Ind. M. V. MILLER.

* * * *

Replying to R.E.G., about the easiest and cheapest way to reduce the speed of a motor is to shift the position of the brushes, but the amount that the brushes can be shifted is, of course, limited, by its effect on the commutation. Where the load is constantly varying or fluctuating it is, of course, not possible to shift the brushes constantly in accordance with the load variation. Due to the fact that increased field strength will reduce the speed of the motor, more wire or turns may be added to the shunt field coil.

A compound motor may be made to run at constant speed, if the current in the series winding of the field is arranged to act in opposition to that of the shunt winding. Then an increase of load will weaken the field and allow more current to flow through the armature without decreasing its speed. Such motors are, however, not very often used, since an overload would weaken the field too much and thereby cause trouble. If the current in the series field acts in the same direction as that in the shunt fields, the motor will slow up slightly when a heavy load is put on, but will take care of the load without much trouble.

Motor speed may also be reduced by inserting resistance in the armature in the form of a speed regulator, the amount of speed reduction depending partly on the amount of resistance introduced into the armature circuit and partly upon the load. The maximum amount of speed reduction is about 85 per cent when employing a resistance in series with the armature circuit, but a reduction as great as this is unsatisfactory, for a comparatively slight increase in the load will cause the motor to stall. The reason the motor runs more slowly in this case is because part of the energy is shunted into the resistance and there dissipated in the form of heat. Whether the motor is operating at full speed or half speed, the amount of current consumed is about the same; in one case all the energy goes into the motor, and in the other some of it is dissipated as heat in the resistance. This objection is partly offset by the fact that speed reduction by the armature resistance method can be applied to any motor of standard design and requires nothing more than a simple and inexpensive speed regulation rheostat. When a motor runs at full speed most of the time, one may feel justified in using the armature resistance method. It may be that R.E.G.'s motor runs faster now after rewinding the coils because the armature winder put fewer turns in each coil, so that he could gain more space in the slots.

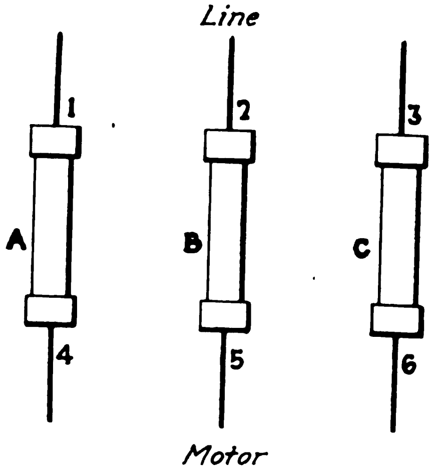
District Line Supt., H. J. ACHEE.
Southwest Light and Power Co.,
Elk City, Okla.

* * * *

Testing Fuses to Prevent Motors Running Single-Phase—We have a large number of three-phase induction motors that are protected by individual fuses placed near each motor. Also, the different branch circuits feeding several motors are protected by fuses. To insure that the motors do not operate single-phase, frequent tests are made of the fuses. Is it sufficient to test the fuses by temporarily connecting a lamp of suitable voltage across the ends of each individual fuse? Will a lamp test across the phase wires ahead of or after the fuses give a positive indication? Will connecting the lamp ahead of one fuse and behind the adjacent fuse give a reliable indication? I should like to have some of the readers discuss these questions for me and point out which is the best method to use for testing under the conditions described and also tell how to interpret the different indications obtained from the lamp.
Newark, N. J. W. S.

While considering W.S.'s question, the writer could not see how lamps could be used to determine whether a three-phase induction motor is running single-phase, because the windings of the motor which are not carrying power current would generate an electromotive force nearly equal to line voltage. This slight difference between the voltage generated in the open phase and the line voltage would not cause sufficient difference in the illumination of a lamp to be readily detectable by the eye. A voltmeter was thought to be a possible indicating instrument for the above condition and a test was made in the laboratory with a 5-hp., 220-volt, three-phase induction motor.

Referring to the accompanying illustration phase *A* was opened while the motor was running (circuit breakers were used instead of fuses, but the conditions are exactly similar). Connecting a 300-volt voltmeter to measure the line voltage across points *1-3*, *2-3* and *1-2* gave a reading of 236 volts in each case. Measuring the motor voltages, *4-5* gave 215 volts, *4-6* gave 215 volts, and *5-6* gave 236 volts. This indicated that the motor was running single-phase and because the low reading of 215 volts resulted whenever a measurement from point *4* was made and the normal reading of 236 volts was obtained in the combination not employing point *4*, the indication was that line *A*, or circuit breaker *A*, was open.



This shows the points across which the voltage was measured to detect a blown fuse in a three-phase circuit.

A further test was made employing the same voltmeter, by measuring the voltage drop across the circuit breakers. In this measurement, *1-4* gave a slight indication on the voltmeter, estimated at about 15 volts, while *2-5* and *3-6* gave no indication. This second method indicated that circuit breaker *A* was open. This second method is probably the easier and quicker of the two methods. In all such tests, a voltmeter whose full-scale deflection is at least as great as the line voltage, should be used. In the first method, the line voltage readings across *1-2*, *1-3* and *2-3* should always be obtained in order to detect any line voltage unbalance, which if not known, might cause misleading values for the motor voltage readings.

All of the above voltmeter connections were repeated with a 220-volt lamp in place of the voltmeter, but the writer could not detect any difference in the illumination of the lamp and hence could not determine the open line by employing a lamp.

In the rather infrequent case of two fuses blowing, these fuses could be located by means of a lamp of line voltage rating. In this case connect the lamp from one of the motor ends of the fuses in turn to any one of the other line terminals, as for example *4* to *2* or *3*, *5* to *1* or *3*, and *6* to *1* or *2*. If the lamp lights, then the fuse in the line to which the lamp is connected on the motor side of the fuse is good and if the lamp does not light, it is not good.

Instructor, H. A. MAXFIELD.
Worcester Polytechnic Institute,
Worcester, Mass.

* * * *

While running a test on a 3-hp., 220-volt, three-phase induction motor, to ascertain certain information relative to W.S.'s question, I obtained the following data:

In order to distinguish between the fuse connections, the terminals of the fuses in phases *A*, *B* and *C* will be referred to as *1*, *2* and *3* respectively on the line side and as *4*, *5* and *6* on the motor side.

When the motor was not running, a reading of 228 volts was obtained between points *1* and *2*, 228 volts between points *2* and *3*, and 226 volts between points *1* and *3*. During normal operation of the motor, 227 volts was indicated between points *1* and *2*, 226 volts between points *2* and *3*, and 224 volts between points *1* and *3*.

While the motor was running single phase, 206 volts were indicated between terminals *4* and *5*, 224 volts between *5* and *6*, 202 volts between *4* and *6*, and 15 volts between *1* and *4*.

Two 220-volt, 60-watt carbon filament lamps connected in series were used in the same manner as the voltmeter. When the lamp terminals were placed across points *5* and *6* the lamps were lighted at half brilliancy. When the terminals were placed across points *4* and *5* and *4* and *6* a difference in the brilliancy of the lamps was easily detectable. When testing with one lamp only, a greater difference in the brilliancy of the lamp was noted. The same lamp test was repeated on a

5-hp. motor running slightly loaded and no trouble was experienced in locating the open phase. R. V. MARTYN.
Auburn, Washington.

* * * *

Thawing Frozen Water Pipes.—I should like to obtain data for building a transformer drawing about 600 amp. on the secondary side, which is to be used for thawing out frozen water pipes. The transformer is to be used on a 115-volt circuit and I shall be grateful if some reader will let me know the size of core to use, the size of wire, and the number of turns on the secondary and primary windings. What should the secondary voltage be, in order to give the best results for my purposes?
Duluth, Minn. F. G. G.

In answer to F.G.G., I am giving the data for a 2-kw., 115-volt, 60-cycle transformer, with an output of 150 amp. at 13 volts, on the secondary side which I believe will serve his purpose.

The sheet-iron core should measure 17½ in. long by 8¾ in. wide, outside dimensions. The thickness and breadth should be 3 in., or 3 in. square.

The primary winding should consist of 80 turns of No. 8 B. & S. gage d.c.c. magnet wire, wound in even layers on one of the long legs of the core, which has been previously well insulated with several layers of Empire cloth.

The secondary coil is wound on the other leg of the core and should have nine turns of No. 0 B. & S. gage magnet wire. Owing to the difficulty of winding No. 0 wire, it would be advisable to wind either two No. 3 or four No. 6 wires, connecting them all in parallel to form a single wire. The efficiency of this transformer is about 95 per cent. R. W. BUCKETT.
Richmond, Calif.

* * * *

Substitute for Crane Collector Bars.—We are having considerable trouble with the collector bars on a floor-type charging crane used for charging skelp into a heating furnace. These collector bars are placed below the floor level and are reached by a collector rigging operating through a slot in the floor. We propose to do away with this method, because of maintenance troubles, and substitute a multi-conductor cable which will run from the crane to some fixed point nearby. Can some reader tell me how to rig up a device for retrieving this cable so as to prevent it from being dragged over the floor or catching on objects placed on the floor? The total travel of the crane is about 25 ft. and the cable must not be carried higher than 10 ft. in the air for there are cranes working overhead that might interfere with the cable.
Gary, Ind. F. U.

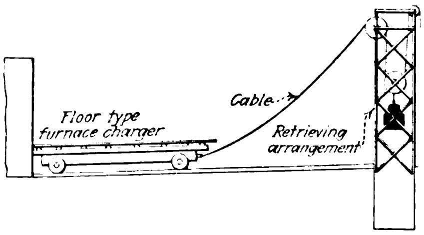
I should like to call F. U.'s attention to the automatic take-up reel manufactured by the Appleton Electric Co., Chicago, Ill. These people manufacture reels for multiple-conductor cables, which are used in connection with various types of equipment, such as locomotive cranes, foundry equipment and electric overhead traveling cranes and hoists. C. E. SCHIRMER.
Chief Engineer,
The Toledo Crane Co.,
Bucyrus, Ohio.

* * * *

F. U. will probably find, with such a short crane travel, that a piece of Tirex cable will answer his purpose admirably. This cable may be installed by attaching it to a few insulators which are strung on a slide wire. The cable will sag between the insulators in a series of short loops, but not enough to dip down in the way. The cable should be fitted on both ends with separable connectors which would open or come apart in case of an accident or a hard pull on the cable, and thus prevent breaking it or the slide wire.
Electrical Engineer, R. P. DIEHL.
Park City Mining & Smelting Co.,
Park City, Utah.

* * * *

In connection with F. U.'s floor-type furnace charger which has a 25 ft. travel, I believe that collector shoes on contact rails below the floor level could be arranged to give the most satisfactory results. However, if a flexible cable is to be used for conveying energy to the motor on the machine, a multiple cable with rubber outer surface, such as Tirex made by Simplex Wire and Cable Co. or Super Service made by the Rome Wire Co., should suffice.



Retrieving arrangement for cable connected to a floor-type furnace charger.

These types of cable will stand dragging over the floor, but as small objects may be placed on the floor, in the way, it is suggested that the cable be run from the charger over a sheave mounted at the top of an angle-iron structure not more than 10 ft. high, as shown in the accompanying illustration. A movable sheave carrying a counterweight should put sufficient strain on the cable to keep it off of the floor as the charger moves toward the retrieving arrangement. Because of the limitation in headroom, the counterweight will have to go below the floor level, but the pit need not be more than about 4 ft. deep.
Pittsburgh, Pa. D. W. BLAKESLEE.

* * * *

Lubricating Ball and Roller Bearings.—I wish to know how thin an oil can be satisfactorily used to lubricate ball and roller bearings used in motors. Do readers prefer the use of grease for these applications and if so, why? What are the desirable characteristics of oils and greases that are intended for use on the roller bearings and ball bearings used in motors?
Youngstown, Ohio. E. L.

In regard to the question asked by E. L., the lubrication of ball bearings on different motors should be studied, as I find that one grade of oil is not suitable for all the motors in our plant. A medium grade of oil, containing a small amount of graphite, may be satisfactory on one installation, while on another where speed may be somewhat slower, a lighter oil is generally found more satisfactory. If there is any doubt concerning the lubrication of a particular motor, it might be well to communicate with the manufacturer of the motor concerning the proper lubricant to be used.
Chief Electrician, E. J. MORRISSEY.
United Gas & Electric Co.,
Aurora, Ill.

How Many Men Are Required for Maintenance in This Plant?—I wish readers would tell me how many men we should have for carrying on the electrical maintenance and repair work in our power house. This plant is a central station isolated from other companies and is self-dependent. It has five generating units: one 20,000 kva., two 6,000 kva., one 3,500 kva., and one 3,200 kva. There are four exciters, two rotary converters, and two 550-volt commercial d.c. generators. The plant also contains three banks of bus tie transformers as well as three 33,000-volt transformers. There are 121 motors ranging in size from 1/16 to 200 hp. at 220 and 2,300 volts, and also a 44-panel switchboard with auxiliary switchboards as needed. This plant has automatic control and interlocking systems and is modern in every respect. Some of the apparatus is three years old. We expect to handle all repair work such as winding and testing, as well as any new installation work that may be required. I am chiefly interested in the number of men required and the particular work that should be assigned to each. Your opinions will be very helpful.
Aurora, Ill. E. J. M.

Referring to E.J.M.'s question, it would seem advisable in my judgment to have the following maintenance men: One electrical superintendent in charge of all maintenance, repair, testing, and installation work; one shop foreman in direct charge over all members of the personnel, two experienced winders, one for a.c. and one for d.c. work (all repair work on motors other than re-winding is to be done by these men also); three experienced testers (a.c. and d.c.) to do testing and general repair work and maintenance on equipment in place; three electrical helpers to work with testers and develop into experienced men; two laborers or plant men to clean equipment, truck motors from location to shop, and be generally useful.

This personnel, naturally, will be enlarged from time to time as requirements develop and this outline is given as a start, or as a skeleton working crew to handle the equipment outlined. Additional duties should be given each man when conditions make this advisable.

The superintendent can be eliminated, if necessary, but one man should be held responsible for the entire work in this department. As a rule, a superintendent will have plenty to do devising methods of procedure, plotting equipment locations, developing a renewal parts file, and the like and also supervising the care of the equipment of the system. I would strongly advise that this position be created as it forms the backbone of the entire organization in the plant.

Under this set-up the shop foreman would, of course, report to the electrical superintendent, and the foreman in turn supervises the laborers or plant men, winders and repair men, and testers and testers' helpers. If outside electrical men are included in the personnel they should have the chief of the crew report directly to the superintendent as a matter of routine.

Of course, a cut-and-dried organization can not be developed on paper, and experience will determine, largely, the extent and duties of the personnel. As the equipment is up to date and practically new no serious trouble should develop and I believe the above crew would be adequate.
NATHANIEL W. BLANCHARD.
Inwood, L. I., N. Y.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Effects of Overvoltage on Contactor Coils Reduced by Using Reactors

VARYING line voltage is the source of considerable trouble with the operating coils of contactor.

These devices are often abused by imposing on them voltages above their rating, with the result that the insulation becomes baked, making a breakdown inevitable. When it is necessary to use an outside source of current, whose voltage is higher than the coils are designed for, or when the voltage of the plant supply is too high, it is well to provide some means of bringing this voltage down to meet the requirements of the contactor coils.

A 5 per cent variation from the rated voltage is all that coils should be called upon to handle, and if the voltage of the supply circuit is more than 5 per cent too high or too low, trouble will likely be encountered sooner or later.

I recall an installation which was put in a few years ago, where the coils were designed to operate on 440 volts, but the supply circuit was badly overtaxed with varying loads, causing serious voltage fluctuations at the coils that resulted in burned-out coils. This fluctuation, which ranged from 480 to 500 volts, amounted to a minimum overvoltage of 10 per cent and occasionally rose to 13 per cent or more. The coils in question were contactor coils on a Westinghouse automatic synchronous motor panel. Outside service of decidedly poor character was used and the fluctuations were due to an overloaded system feeder carrying 60-cycle a.c. current.

To protect the coils a reactor was chosen in preference to a resistor, partly because we had no resistor on hand, whereas the parts for a reactor were available.

The number of turns required for the reactor was first based on a guess. After the reactor was connected up the voltage of the supply circuit and at the coil terminals of the coils was checked by a voltmeter. The difference in the readings was divided by the number of turns in the reactor which gave us the correct value per turn, after which we added enough turns to obtain the result desired.

The contactors operated by these coils weigh about 350 lb. per panel. There were four panels per board, or a total of six panels, including the operating panels.

As we were not designers of reactors, we measured the area of the iron in the contactor core and put the same amount in our reactor.

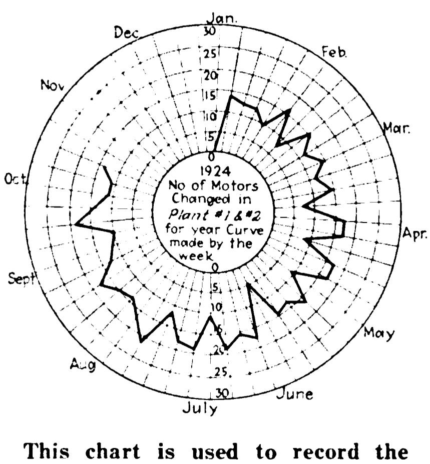
The iron core was obtained from a discarded transformer and probably could not be considered the best, but it served our purpose. The number of turns to be used was another item that a designer could state in a few minutes, but in our case we experimented with wire the same size as that used in the contactor coil, until we were satisfied. The voltage was cut to the proper value, and thereafter no more coils were destroyed.

As ours was but a temporary arrangement, the iron was stacked in the usual manner, but in the form of a square, in order to use the iron without cutting. The corners were held together by C clamps and the unit was supported by glass-insulated spools.

Chief Electrician. E. J. MORRISSEY.
Western United Gas & Electric Co.,
Aurora, Ill.

Method of Recording Number of Motors Removed

IN THE electrical department of a plant having about 1,500 motors operating under severe conditions, a chart was made up to record the number of motors removed for any and all causes, in order to observe graphically the trend of plant conditions and amount of work performed. A circular chart was selected for convenience and a tracing is made once a year in ink on tracing cloth; then the necessary blueprints are made up. The curve showing the number of motors changed is filled in weekly for the office record with red pencil. At monthly intervals the tracing is inked in and after blueprints are made they are sent to the officials interested. The inside circle on the chart is 2½ in. in diameter, the radius of the circle being increased 1 in. for every ten motors. The chart may be conveniently laid out with an engineers' scale and compass.



This chart is used to record the number of motor removals.
The various points on the curve are plotted weekly.

J. ELMER HOUSLEY.
Electrical Engineer,
Aluminum Company of America,
Alcoa, Tenn.

Low Voltage Supply Cause of Puzzling Motor Trouble

SOME time ago one of the electricians in our shop was sent to a bottling works to find the cause of trouble on a pump motor. This motor was a 15-hp., 220-volt, 1,800 r.p.m., a.c. machine and was made by a reliable manufacturer. The pump was of the centrifugal type and of a well-known make, and was direct-connected to the motor through a rigid coupling.

The electrician who examined the motor was a capable man and made all kinds of tests for the source of the trouble, which appeared to be unusual. The motor started normally and ran all right without load, but when the pump discharge valve was opened, it slowed down perceptibly. Although the motor was not overloaded it would begin to heat immediately and in 10 or 15 min. was abnormally hot. Without a doubt, the motor would have burned up in an hour or so, running with load.

The electrician tested for bad contacts in the starter, in the line relays, and main switch; any contacts that looked at all loose were tightened and the motor leads were also gone over. When these efforts did not eliminate the trouble, mechanical defects were looked for. The bearings were examined and found to be low. The rotor was removed, new bearings were made, the rotor replaced, and the pump and motor shafts carefully aligned. This remedy did not bring the desired results; so a machinist was sent to examine the motor and pump for mechanical defects. He checked each part carefully but found nothing wrong.

It was then decided to send another man over to look at the motor and see if he could find the trouble. Anyone who has dealt with such troubles knows that a man can stay on a job like this one until he becomes fagged out and cannot do his best work. The second man comes fresh on the job, with all the facts the first man found, and has only to check these facts before proceeding with his own ideas or experiments. Any man who "shoots trouble"

knows that oftentimes his results are gained by cut-and-try methods, especially when the trouble is obscure. He probably finds some minor trouble, corrects it and tries the mechanism to see if it functions properly; if it does he makes several trials to make sure that it did not just happen accidentally. If it functions properly every time, the chances are that he has remedied the trouble; if not, further investigation is necessary.

The second man sent had an ordinary magneto and a 220-volt test light. To satisfy himself he made all the tests that had been previously made. Finally he tested the voltage with his test light, as he did not have a voltmeter. The light burned brightly and apparently the voltage was normal. It then occurred to him to leave the test light on the switch and start the motor. With the motor running the test lamp burned a dull red.

This man at one time worked for the power company and knew several of the foremen; so he asked the foreman in charge of this particular district to come and test the voltage.

When a meter was attached to the switch it showed about 212 volts, with the motor at rest. But when the motor was started and the load put on, everyone was surprised to find that the voltage supply had dropped to 160 volts. The power company agreed to make transformer changes that would eliminate the trouble, and also to increase the line voltage or make any other changes necessary to deliver the power required.

When these changes were made the following day, they brought us another small job. A single-phase motor at a bakery ran hot; in fact, it smoked. The man who solved the bottling works trouble was sent to this job, and with voltage testing fresh in his mind made the same test and found the voltage at the motor to be 220. This motor was wound for two voltages, with the leads brought out in the usual way, and had been connected for 110 volts. The 110-volt connection probably was made when the 220-volt supply dropped to 160 volts. When the motor was reconnected for 220 volts it operated satisfactorily. GRADY H. EMERSON.
Birmingham, Ala.

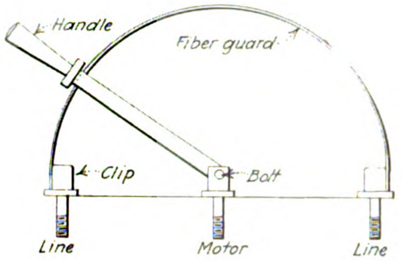
Method of Using Fiber Guard to Prevent Arcing Between Switch Blades

ANSWERING an emergency call from our substation, one night, I found that the operator had a badly burned arm, and a rotary converter motor starting switch was burned up.

A few questions brought out the fact that the operator had been cleaning the converter and, desiring to give the armature a half turn, he had momentarily closed the motor switch.

As the motor was rated at about 25 hp., 400 volts, and had the whole 1,500-kw. transformer bank back of it, the thoughtless closing of the switch resulted in an arc that was brief, snappy and directly to the point.

To avoid a repetition of this accident, barriers were made up from ⅛-in. black fiber in the form of a half circle, and



This knife switch is equipped with fiber barriers to prevent arcing between blades.

then were mounted between the switch blades in such a way that the crossbar of the switch would just clear the barriers, as shown in the accompanying illustration.

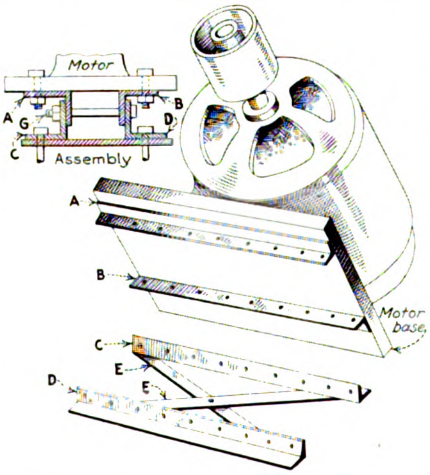
As a further precaution, a hole ⅞ in. in diameter by ¾ in. deep was bored in the armature shaft near one end, and a heavy spanner wrench was furnished so that there would be no inclination to "inch" the armature with power.

Electrical Engineer, PHILIP N. EMIGH.
The Mountain Water Supply Co.,
Indian Creek, Pa.

Simple Method of Constructing Improvised Motor Base

RECENTLY an emergency job made the installation of an additional motor necessary. Although a motor of the proper size and speed was found to be on hand, no suitable slide rails or base could be located. There was no time to await the arrival of a base from the manufacturer; so it was necessary for the electrical crew to devise a substitute base. Eventually the base, shown in the illustration was built.

This base consists principally of two pieces of 3-in. by 3-in. angle iron which were cut 20 in. long, and two pieces of 4-in. by 4-in. angle iron each cut 24 in. long. Four bolt holes were spaced on pieces *A* and *B* so as to match up with the holes in the frame of the motor. The other holes in these two pieces, *A* and *B*, were spaced 1½ in. on centers.



The motor base was made from angle iron.

A and *B* are pieces of angle iron 3 in. wide by 20 in. long. *C* and *D* are 4 in. wide by 24 in. long. Two bolts, *G*, secure the motor in a position after the belt has been tightened.

These two angle irons were then bolted to the motor, as shown.

The 4-in. by 4-in. angle irons were braced by pieces of strap iron, *E* and *F*, the holes in the other flange of these angles being spaced 2 in. on centers. After assembling the various parts of the base, it was then easy to take up belt slack ½ in. at a time, due to the difference in the spacing of the holes in the vertical parts of the angles, one set being spaced 1½ in. apart and the other set 2 in. apart. Two bolts, *G*, were used to hold the motor in place, after taking up slack in the belt.

This device was quite satisfactory, except when we had to take up slack in the belt, for it was then necessary to use a jack to draw the motor back so that the bolts, *G*, could be inserted. However, a screw to take up the slack could easily have been added, although it was not done on the job just described, for a new slide base had been ordered and would eventually take the place of this arrangement.

Chief Electrician, CHAS A. PETERSON.
U. S. Gypsum Co.,
Alabaster, Mich.

Comment on "One More Reason for Standardizing General-Purpose Motors"

WE HAVE been much interested in your editorial published under the above head in the October, 1923, issue, and also in the various comments made on it. Our company, a number of years ago, realized that the many changes in designs of motors reacted most unfavorably upon the user; hence in bringing out our Type T direct-current motor in 1915 we laid down a policy that any future improvements made in this motor must be interchangeable with the original design in mounting dimensions as well as be capable of utilizing the spare parts used on older types of motors, and which the user might have in stock.

The success of this policy was demonstrated at the Philadelphia Convention of the Association of Iron and Steel Electrical Engineers in 1925. Here was exhibited the first Type T motor shipped from our factory in 1915. Beside it stood a duplicate motor, just off the test floor. Many improvements in design were noticeable. Brush-rigging, field and armature construction, bearing enclosures, and other parts had been kept up to date in every respect. In spite of these changes, every part of the two motors could be interchanged. Spare parts bought in 1915 could be applied to the 1925 motor.

It was comparatively easy to follow the same policy on alternating-current motors, and since our Type AA line of squirrel-cage motors was developed in 1920, we have been successful in making improvements in design and manufacture that have not affected the interchangeability of the parts of our product.

Our customers have commended us so highly on this policy that we intend to adhere to it and give them what we believe to be real standardization.

President, CLARENCE C. COLLINS.
Reliance Electric & Engineering Co.,
Cleveland, Ohio.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Experiences with Anti-Friction Bearings in a Flour Mill

IN OUR 2,400-bbl. flour mill, all of the rolls, scourers and separators are equipped with ball bearings in order to eliminate friction, and, after 12 yr. of service in charge of this mill, I can frankly say I am a friend of the so-called anti-friction bearings, because they save power, oil, and a large amount of labor which would otherwise be required to repair the machines and keep them clean and well oiled. Also, the rolls are always running cool, which means continuous operation and results in more and better production every day. The ball bearing has come to stay, I believe.

We are in a progressive age and are always looking for something better, although after 12 yr. of continuous operation, night and day, I now have over 75 per cent of the original ball bearings in use and these are still giving good service in spite of the constant jar and vibration a flour mill roll bearing is subjected to. For the past 2 yr. I have been trying out some of the Hoffman roller bearings, and so far they have given good results. I like the principle of the roller bearings and believe that they are better in certain places especially where the bearing is not rigid but is subjected to a continued jar and vibration, because it has more contact, both on the inner and outer races. Ball bearings have a point contact and roller bearings have a full line contact, according to the length of the rolls. Within a few years I think practically all machines, at least in my industry, will be equipped when built with either ball or roller bearings because they operate better, last longer and are cheaper in the long run than plain bearings. Also, their use results in big savings in power, oil, and labor, and, in addition, the flour machine will last much longer. In our industry labor is the greatest operating expense and we are always trying to reduce it wherever possible. Power expense is the next big item with us and the improved bearings help to reduce it. This mill is consuming less than 5.5 kw.-hr. per bbl. which includes all power used in the mill elevators, all light, and a considerable amount of heat in the office and laboratory.

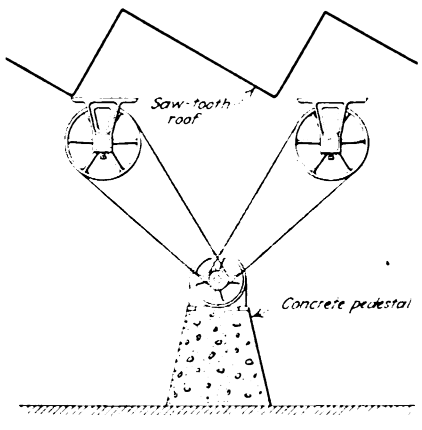
Men in charge of industrial operation should study their power consumption per unit and compare it, if possible, with other plants. Even with a favorable comparison they should investigate thoroughly all equipment to discover any unnecessary losses. In many cases they would find that if they would install improved bearings and take other measures to reduce the power loss that they are paying for each year, the savings would make it a good investment.

Superintendent, J. HANSON.
The Wichita Flour Mills Co.,
Wichita, Kan.

Method of Driving Two Shafts from One Motor

THE more common method of connecting two lineshafts to be driven by a single motor is to belt the motor to a jackshaft, which is usually placed between the two lineshafts, and drive both from it, or to belt the motor to one shaft and drive the other shaft by belt from the first. The first plan requires the erection of an additional jackshaft, while the second method requires that the first shaft be heavy enough to take the full load, although half of it may be transmitted directly to the second shaft.

The accompanying illustration shows a third method of arranging a single motor drive for a pair of parallel lines of shafting which is used at the Poughkeepsie, N. Y., plant of the DeLaval Separator Co. These shafts are located in a single-story building with saw-tooth roof and the lines of shafting follow the valleys of the roof, with the machine tools aisled off in a similar manner. Each pair of shafts is driven by a single d.c. motor, which is located alongside the main longitudinal aisle at one side of the room and at the end of the shaft. Each motor is mounted on a substantial concrete pillar, as shown in the sketch, which lifts the motor above the floor dust and high enough to be safely out of the way of passing traffic. The pulleys are higher than the head of a tall man, but still not too high to be convenient for giving any necessary attention to the motor. Testing, oiling and inspection can be carried out by standing on a light portable platform without the risk and time loss that accompany work from a ladder.



Group drive arrangement for driving two lineshafts from a single motor.

By mounting the motor on the concrete pedestal, it is raised above the floor line, so that it is not likely to be damaged by passing trucks. However, the motor is not too high to be easily accessible.

It is usually considered poor engineering to run two belts off the same pulley or to operate belts in such close proximity, chiefly owing to the chance of their fouling. However, no difficulty has been experienced and the belts keep on running safely year after year with not more than an inch between them. One reason for this satisfactory operation is because the heavy driving belts are kept in good condition and so do not run wavy or deviate from a single path of travel.

Advantages of Using Oilless Bearings on Loose-Pulley Drives

OILLESS bearings, which do not throw the lubricant, particularly wood bearings like the Arguto, have found considerable favor in textile and food plants. Many master mechanics will object to classing wood bearings with metal, so far as life is concerned, and will, perhaps, back up their claims by data on countershaft loose pulleys with wood bushings and with some form of metal bushing operating under similar conditions.

Often the wood bushing does not last so long as those made of metal, but a study of its use in the textile industry brings up a point worthy of consideration by master mechanics in many other lines. In this discussion, mainshaft bearings or split bearings are not considered.

The wood bushing has the advantage of taking all the wear, and does not wear the shaft. In the cotton and the silk mills, many machines are driven by clutches and through three-pulley drives, in which a loose pulley is placed between two tight pulleys, one of which is driven by a crossed belt. Often, the clutch drives are direct from mainshaft to machine.

A loose pulley on a mainshaft or the loose pulley in a three-pulley drive will wear the shaft smaller in time, depending upon the speed, the load, and the material which is in contact with the shaft. When this occurs, there is no good way of bringing back the original

fit; although the pulley or the clutch is bushed, the inside diameter has to be large enough to pass over the original shaft size and then when it gets to its position it is a poor fit because the shaft under it is worn.

One remedy is, if possible, to turn down the shaft from the cleared-up loose-pulley position to the end and make the loose-pulley bushing to fit When this is done, one of the tight pulleys has to be bushed down also. Where this practice is followed the operating men will soon find themselves in a nightmare of odd shaft sizes.

It is because of these conditions that wood bushings have found favor. They become worn, but they leave the shaft of standard size. All the maintenance necessary, after the pulley is removed, is merely a 5-min. session on the arbor press. Added to this, is the saving in time through not stopping to oil up, and the freedom from damage to textiles through the absence of oil dripping. For these reasons many operators will find it to their advantage to investigate the possible uses of wood bearings in their industry particularly where oil damage is a serious factor. There are of course, other ways of overcoming this difficulty with loose pulleys, but most of them require scrapping the existing equipment.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Power Grease Gun for Outside Use in Cold Weather

APPLYING lubricants to a number of back-geared motors using a heavy oil or grease is an operation that takes considerable time, particularly where the casing has been cleaned out and is to be refilled. This problem is especially difficult in cold weather. In addition, if done by ordinary methods, the greaser usually gets as much oil or grease on the outside of the machine, and on himself, as on the inside. This surplus lubricant, which is seldom removed properly, catches dust, particularly in dust-producing plants, such as in the lumber industry with which I am connected. Dusty or greasy gear cases not only indicate poor industrial housekeeping, but often are not seen by inspectors or others who are likely to brush against the casings and smear the dust-covered grease or oil over their clothes and themselves, which does, not tend to improve the disposition of the worker toward the machine.

In the winter months when the temperature is low the difficulty of lubrication is aggravated in that it is next to impossible to get heavy oil to flow through the small openings provided in the casings of reduction gears and other similar equipment.

With the above conditions in mind, the grease gun shown in the accompanying sketch was made up. The actual cost was around $25. The parts necessary for construction were picked up around our scrap pile, which has a duplicate in practically any plant. The main grease cylinder was made from a piece of 8-in. pipe, 26 in. long. This was bored out on the inside to a smooth finish. A plate was welded to the bottom and tapped out at the bottom for the air pipe shown in the sketch.

A ring of ½-in. steel plate was welded to the outside of this cylinder about 8 in. from the top, as shown. The top cover was made from a circular piece of ⅝-in. steel plate which was grooved on the under side to fit over the end of the cylinder. Packing and eyebolts, which fit into the slotted circumference of the plate and are held down with thumbnuts make this top joint air tight, but it can be removed easily for filling.

The piston is made in three parts, with cup leathers in between, and bolted together in the center, as shown in the cross-section sketch at right. These cup leathers are the same as are used in the air cylinders on the logging cars and a supply of them is kept in stock. Once installed, the leathers should last indefinitely.

The piston fits so tightly in the cylinder that it was necessary to use a compression thimble to insert the piston. This thimble consists of a ring about 4 in. wide with the inside diameter at one end the same as the inside diameter of the cylinder. This diameter gradually tapers out, somewhat like a funnel, until it is about 1 in. wider at the other end. This taper assists in forcing the leather cups into the cylinder.

When the gun is empty the piston can be forced to the bottom of the cylinder by air pressure. With the piston at the bottom of the cylinder all valves are closed and the top removed by loosening the thumbnut. This gun holds nearly 4 gal. of oil. Practically all grades of cup grease or 600 W oil can be handled easily.

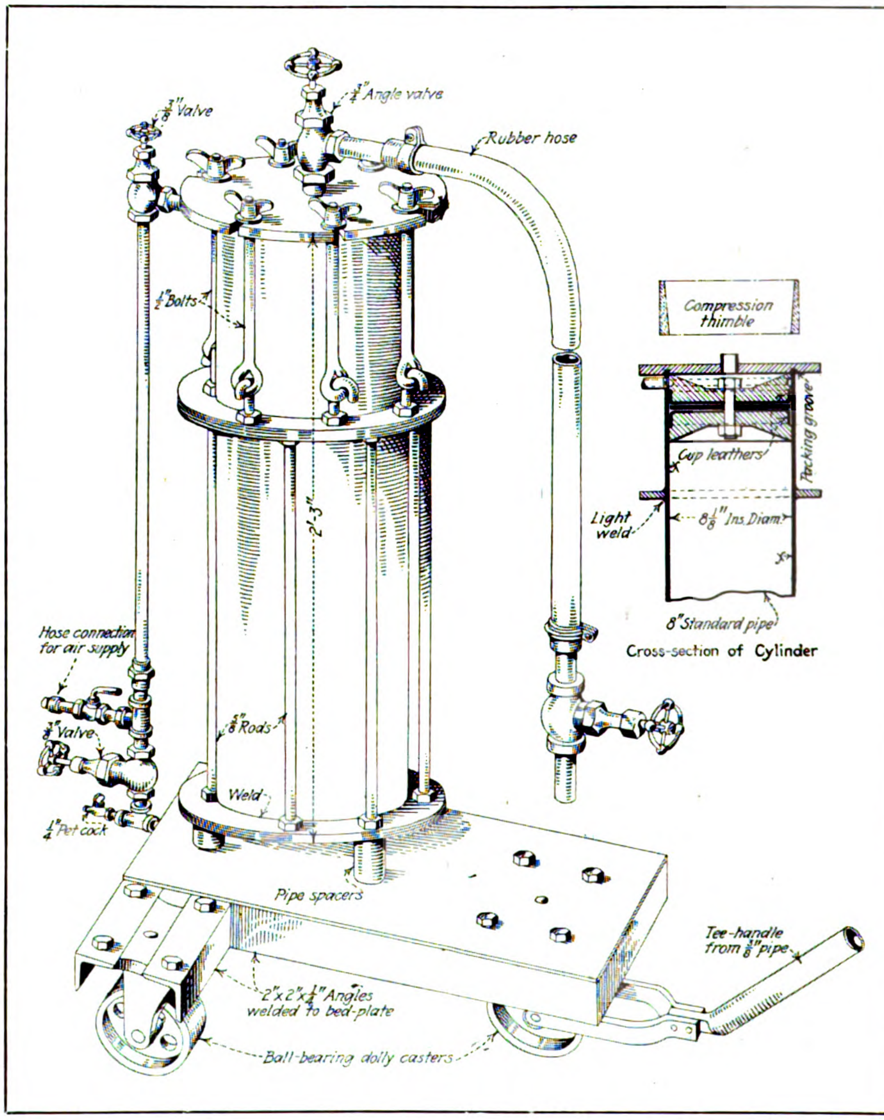
This cylinder is mounted on a three-wheel dolly with ball-bearing, swivel casters and is fitted with 50 ft. of air hose and 10 ft. of 1-in. grease hose with a reduction to ½-in. opening at the outlet valve for an air pressure of 60 lb. Air pressures up to 125 lb. can be used, but with a smaller grease hose or outlet opening.

WM. B. CONE.

Chief Electrician,
The Shevlin-Hixon Co.,
Bend, Ore.

Construction of a gun for filling oil or grease reservoirs by compressed air.

The cylinder holds about 4 gal. of lubricant which is forced out by compressed air. To fill, push the piston to the bottom of the cylinder by admitting air to top of cylinder. Remove the head by loosening the thumbnut on the eyebolts and fill the cylinder. Replace and tighten the head. To operate, admit air to bottom of cylinder, thus forcing the piston up and the grease out through the end of the hose.



In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Inexpensive Method of Making Varnished Tubing

VARNISHED tubing can be made by a simple method that has proved to be a money saver. The first step to take in the making of these tubes is to cut short lengths of wire or rod 3 ft. in length with a diameter equal to the size of the tubing desired. Common white sleeving, of a size that will fit quite loosely over the wire, is slipped onto the wire. Care must be taken not to pull the sleeving tightly. This is important in order to be able to remove the finished tubing easily after the varnish has been applied.

The next step is to apply the varnish. A piece of pipe 3½ ft. long is fitted with a cap at one end, and filled with a quick air-drying varnish. I find Sherwin-Williams' Ajax No. 19 very satisfactory, as it dries quickly. Shellac can be used, but is not so flexible. The sleeving is first dipped in varnish and hung up to drain and, when dry, it will slip off the wire quite easily. Dip again in varnish, but without the wire core. When the tubing is dry it is ready to use.

There are many places where this tubing can be used to advantage, especially in rewinding stators. Time can be saved by slipping tubing over the group connections, after the winding is all in place, as is commonly done on factory-wound machines. The tubing can also be slipped over the pigtails, instead of taping. Any boy around the shop should be able to make up quantities of different sizes of tubing at very small cost. R. BUCKETT.

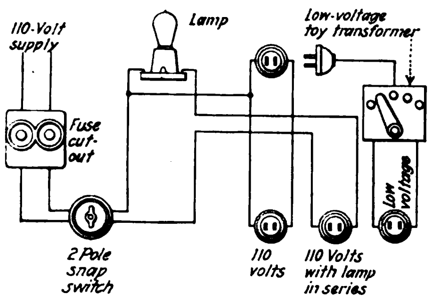
Richmond, Calif.

Easily-Made Test Panel Giving Choice of Several Voltages

EVERY repair shop requires some form of test board which may be used to supply various voltages used in shooting trouble or otherwise testing repaired apparatus. The test board shown in the accompanying diagram provides a supply of 110 volts, having a lamp connected in series with it, and a low-voltage supply ranging from 20 to approximately 6 volts. This board is made up of very simple apparatus that can be readily obtained in the average shop.

The accompanying diagram shows the layout and wiring for the test board. Protection is provided by means of a fuse cutout, and the power may be turned off the panel by means of a double-pole snap switch. Three plug receptacles are provided under which should be stencilled the voltage of the power supply which is wired into it.

The low voltage is obtained by means of a toy transformer. A bellringing transformer may be used if desired, but in this case only one voltage can be obtained from the transformer. Toy transformers such as are used for operating electric trains provide several voltages by means of a small tap switch and use may be made of this to deliver several voltages.



Here is a simple test panel that will meet the requirements of many small repair shops.

Considering the simplicity and value of such a test board, no small repair shop can afford to be without one. NATHANIEL W. BLANCHARD.

Inwood, N. Y.

Method of Eliminating Trouble with Rotary Converter Due to Poor Contacts

BECAUSE of an experience which I had with a 1,150-kw. rotary converter, the following account of how trouble was overcome by making good mechanical joints may be of interest to other readers of INDUSTRIAL ENGINEER.

This particular machine would develop black spots on the commutator bars under alternate poles and was subject to sparking. Grinding helped temporarily, but the worst trouble was encountered with the six collector rings. The converter had been repaired several times, but would run for only about six months before it would flash-over and ground. This made it necessary to disconnect all the rings, pull off the hub and sometimes order new rings from the factory.

By inspecting the machine very carefully before stripping, it was discovered that the studs were loosely threaded into the ring and that the connections from the armature coils to the studs were very poor. The vibration of the machine in addition to the expansion and contraction during 24-hr. service caused the joints to work loose. Oxidation of these loose parts was responsible for such poor contacts that some of the studs carried more current than their capacity. The result was poor operation, and when the trouble developed to a certain stage, the studs melted off, causing an arc.

To overcome this trouble the six rings were removed, two being cracked when the arc occurred. As this was a rush job, it was necessary to have these two rings cast in a local foundry and machined in our own shop to save time. All the threads of the old rings were drilled out and the holes were reamed to a uniform taper. New studs were made and tapered to fit snugly in the rings. On the ring end of the studs a thread was cut and a lock-washer and nut put on, which would take up the slack caused by the ring expanding from the heat. This washer assured a mechanically solid joint at all times and good contact without the aid of solder. It is not advisable to rely on solder alone in such cases, and to make sure there would not be any trouble at the contact between the studs and connectors, all of the connectors were drilled and a bolt put through them. In this way we could clamp the connectors to the studs and thus make a good electrical connection.

To give additional mechanical strength, a hole was drilled through both connectors and studs, a bolt put through and the joint soldered. This eliminated the danger of the connectors becoming loose when the machine was running at 1,200 r.p.m. Once a month the machine is stopped and inspected for loose nuts, but so far none has been discovered.

Replacing the rings on the hub of a machine of this size was difficult with the equipment in the average repair shop. We did it in the following manner. It was necessary to put three layers of 0.03-in. and two layers of 0.02-in. molding mica on the hub, which was heated slightly. The first layer of mica was shellacked on and the hub then rolled over a smooth piece of iron. The weight of the hub helped to compress the mica tightly. The five layers of mica were put on in this manner. Steel band wire was then wound over the mica the entire length of the hub. Before the banding wire was fastened a small pulley was slipped over the end. A heavy weight suspended from this pulley served to tighten the wire as it was being wound on the hub. For further details of this procedure see page 409 of D. H. Braymer's book "Armature Winding and Motor Repair."

Heating the hub with a torch helped us to get the mica on solidly. When the hub cooled off, the steel band was removed, the mica sandpapered and six small bands wound on each position where the rings were to set. After this, the bands were soldered and smoothed off in the lathe. The object of the bands was to make certain that the rings would adhere more closely to the mica. By boring out the rings a few thousandths of an inch smaller and shrinking them over these bands, we felt certain that they would stay in position when the machine was in operation, and this proved correct.

All of the old coils were stripped from the rotary, cleaned in a lye tank, retinned and taped by hand. The rotary was rewound, the rings assembled and the machine was back in service within 16 days from date of breakdown. Most of the time four men worked on this job, but never later than 10 p.m. This machine has been operating day and night for about nine months, and is stopped once a month for cleaning and inspection. No signs of black spots on the commutator or sparking have been noticed, which is sufficient proof that the trouble was eliminated.

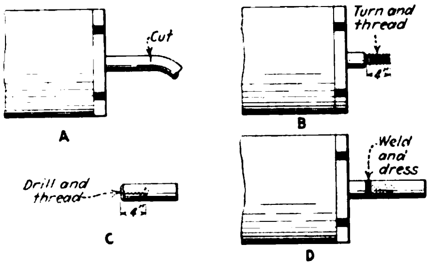
We have handled similar cases of trouble on other rotaries in the same way and I believe it is safe to say that manufacturers of rotaries could eliminate most of our troubles by paying more attention to the a.c. side, in regard to better mechanical joints before soldering. Repair men oftentimes do not go far enough to determine the cause for failure of a certain machine. If a coil is burned out or a stud burned off he replaces it and considers that is all that is necessary. However, allowances should be made for occasional faulty design or errors which might have been overlooked by the factory inspectors. NICHOLAS J. WEISS.

West New York, N. J.

Quick Method of Straightening Emery Grinder Shaft

INSTEAD of waiting for a new shaft from the factory, D. N. Bryan explained in a recent issue of *Suggestions* (The Lincoln Electric Co., Cleveland, Ohio), how the shaft of a motor-driven grinder was straightened at the plant. This shaft was badly bent, due to a tool being caught between the guard and the wheel, the bend in the shaft being just outside of the bearing. The shaft was repaired in the following manner.

The rotor was removed from the motor and the shaft cut just behind the bent portion, as shown at *A* in the accompanying illustration. The remaining shaft was then turned down to about 25 per cent of its diameter for a distance of about 4 in. from the end, as shown at *B*. This part was threaded its entire length and a piece of mild steel, shown at *C*, was turned, drilled and threaded. This piece was then screwed onto the rotor shaft, and at the junction point of the two pieces a V-shaped groove was cut to the same depth that the shaft had been turned down. The groove was then "filled"



This grinder shaft was straightened by replacing the bent portion with a piece of mild steel.

The bent portion of the shaft was cut off, as shown at *A*, the end of the remaining portion of the shaft being threaded, as at *B*, so that a new piece of shaft *C* could be screwed onto it. The two pieces were then welded together, as at *D*.

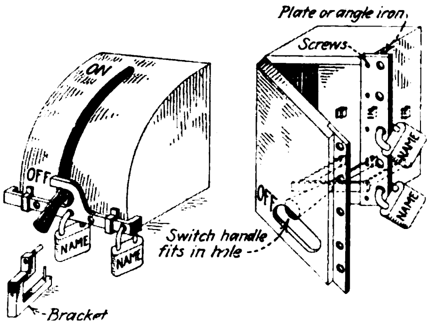
and the shaft made into one piece by electric welding. After this work on the joint was finished by truing up in a lathe, the emery wheel was ready for service.

This method will prove satisfactory for lengthening shafts, as well as for straightening them.

Converting Knife Switches from Enclosed to Safety Type

TWO practical methods of converting the open or enclosed type of knife switches to safety type switches are explained below. The method to be used in a given case will depend primarily on the style of switch housing employed.

A switch fitted with a housing similar to the one on the left in the accompanying illustration can be secured in the "off" position by employing a strap made from $\frac{1}{8}$-in. sheet iron bent to the proper shape. This strap is locked in position by means of one or more padlocks, the number depending upon the number of men working at different places on the line controlled by this switch. Just as soon as a man completes his work on the line he removes his padlock, thereby keeping the line "dead" until the last man has completed his work. The strap that holds the switch handle in the "off" position may or may not be bent at the ends, but should have holes in it, to accommodate



Here are two inexpensive ways of changing enclosed knife switches to a safety type.

Where the half circular type of cover is used and the switch handle is visible at all times, the switch may be secured open as shown at the left. The box type of cover has a slot in it so that the switch handle can protrude through it when the switch is open.

several padlocks. Each man or group boss should be supplied with a padlock marked with his name, number, or other means of identification, and with a key to fit it.

A switch enclosed by a box similar to the one on the right in the sketch can be secured in the open position by allowing the switch handle to project through a hole marked *OFF* in the cover, the cover being fastened by one or more padlocks. Two pieces of strap iron or angle iron are used to hold the cover closed, holes being bored in the iron to accommodate the padlocks. When the switch handle is seen protruding through the cover of the box there will be no doubt as to whether the switch is open or closed.

Oakland, Calif. S. H. SAMUELS.

Easy Method of Changing Speed of Wound Rotor Induction Motor

SOME time ago it became necessary for us to change the speed of several G.E. motors from 600 to 900 r.p.m. The data on these motors were as follows: Type I, Form M, 150 hp., three phase, 440 volts, 600 r.p.m., rotor winding of the wave type, size of conductor approximately $\frac{3}{32}$ in. by $\frac{1}{2}$ in., two bars in parallel. The winding was connected three-circuit star, and the pitch of the stator coils was 1-and-10.

A definite procedure was followed while changing the speed of these motors. First of all the motors were dismantled, and the stators carefully stripped. The coils were then placed in the spreader and pulled out to give a coil pitch of 1-and-12. The stator was then rewound, the coils being grouped for eight poles, and later connected four-circuit star.

The two outer steel bands on top of the soldered clip joints at the ends of the rotor barrel winding were removed and the varnish thoroughly cleaned off the clip joints. Copper filling pieces, slightly tapered, were then made and after being tinned were driven in radially between the clip joints. These filling pieces formed a light ring of copper on each end of the rotor winding. The cross-section of each ring was approximately $\frac{3}{4}$ in. by $1\frac{1}{4}$ in. These filling pieces were then made into a solid mass by pouring half-and-half solder over them. The steel bands were well insulated and replaced. The slip rings and all the connections thereto were left intact but the brushes and brush-gear were stripped from the motors.

Over a period of about four years' continuous service on ball mill drives, where the load averages 170 hp., these motors have operated very satisfactorily, and without failure. The method outlined above appealed to the writer as being the cheapest and quickest way of obtaining the desired result. This method of changing over the motors has the further advantage of leaving the rotor in such condition that it can be readily changed back to its original condition for 600-r.p.m. operation.

THOMAS JORDAN.

Garfield, Utah.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Deep-Groove Ball Bearings

MARKETING under the name of Schubert of a new type of deep-groove ball bearing in standard sizes with both double and single row, is announced by the McGill Metal Co., Valparaiso, Ind. One of these bearings is shown in the accompanying illustration. It is claimed that the dimensional tolerances of these bearings have been reduced to approximately one-half of the standard S.A.E. tolerances and that particular attention has been given to the finish of the high-carbon, alloy-

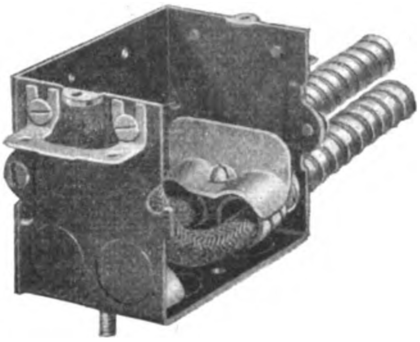
Schubert deep-groove ball bearing

steel surfaces of the races and the balls. The bearings are of the deep-groove, non-filling, slot type, which, it is said, are capable of carrying axial or thrust loads in either direction.

The retainer for the bearings is made of McGill metal, which is a modified aluminum bronze that, it is stated, may be die-cast within very small tolerances and has physical properties closely approximating mild steel. The manufacturer states that the decrease in weight of the retainer, which results from using this metal, is important, especially at high speed. He also states that the high inherent heat conductivity of the bronze tends to dissipate any heat developed.

Adjustable Clamp for Sectional Switchboxes

ACCORDING to the manufacturer, the Chicago Fuse Mfg. Co., Laflin and Fifteenth Sts., Chicago, Ill., the clamps on the new Gem XC sectional switchboxes not only secure the sheathed and metallic cable or loom, but at the same time close up any knockout hole space not filled up by the incoming cable or loom. Also, it is stated that this new clamp has an ex-

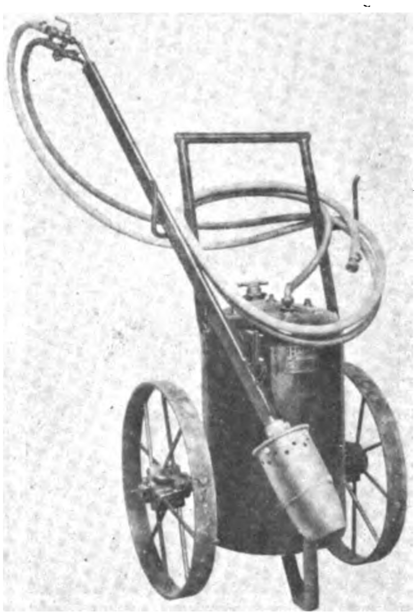


Chicago Fuse Mfg. Co.'s. Gem XC sectional switchbox.

tension so that as the screw is turned down this extension covers the openings, if any, depending upon the size of the cable used. The Gem sectional boxes manufactured by this company which are equipped with this new No. 7 clamp are the XC, the Locktite XCT, and the bracket box XCB. The accompanying illustration shows the XC box.

Preheating Torch

THE portable, two-wheeled venturi suction preheating torch shown in the accompanying illustration is announced by the Hauck Mfg. Co., 126-134 Tenth St., New York, N. Y. The burner is made of sheet steel and pipe,



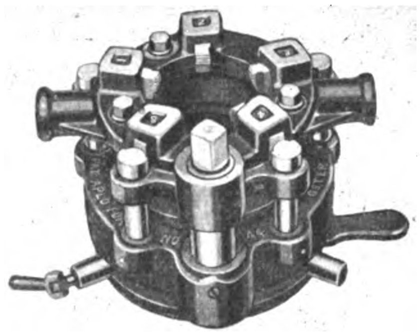
Hauck venturi suction preheating torch.

and the nozzle of cast iron. The construction and operation are described by the manufacturer as follows: The tank is made of seamless-drawn, pressed steel, with bottoms interlapped and brazed; all fitting connections are welded.

The torch can be operated 14 ft. above the fuel level in the tank. The torch operates on fuel oil as heavy as 28 deg. Baumé, it is stated, or on all lighter oils and distillates. Only the usual air pressure of 50 to 100 lb. per sq.in. is required. There is no pressure on the oil to the burner. It is asserted that should the oil line be cut, the oil flow stops instantly because suction is broken and that the same is true should the air line be cut. It is stated that the Hauck Venturi suction torches have been approved by the Underwriters' Laboratories, and the Factory Mutual Insurance Company's Laboratories.

Receding Diestocks

DEVELOPMENT of the No. 44 new receding diestock for 2½-in. to 4-in. pipe inclusive, has been announced by The Oster Manufacturing Co., Cleve-



Oster Manufacturing Co.'s No. 44 receding diestock.

land, Ohio. The tool is geared and is furnished with a ratchet handle so that, it is stated, one man can cut 4-in. pipe. Other operating features as given by the manufacturer are as follows: A leader screw, protected by a patented chip shield, starts the dies on the pipe and pulls them along. Adjustment for deep or shallow threads is obtained by a rotary movement of the die head. The bore of the stock is large enough to allow a 4-in. coupling to pass through and thus permits the threading of short nipples.

Gravity-Lowering Chain Block

MARKETING of a gravity-lowering chain block is announced by Herbert Morris, Inc., Buffalo, N. Y. It is stated that steel plate and forgings are used in its construction. The worm has a double thread and is turned from a solid steel shaft and heat-treated, hardened and ground. Ball bearings are used for the end thrust on the worm shaft. The load-chain wheel and worm wheel are made in one piece. An automatic brake on the worm shaft sustains the load whenever the hand chain is

released. A centrifugal brake keeps the lowering speed within safe limits when lowering by gravity. Over-lowering is prevented by an automatic stop which applies the brake as the hook reaches its lowest point. This unit is rated at 1 ton, but, it is stated, has a considerable margin of safety.

For hoisting only a light pull on the hand chain is necessary. To lower by gravity, a pull on the gravity lowering handle releases the automatic brake. The hand chain does not move when lowering by gravity. However, the load may be lowered by pulling on the hand chain, as is necessary when adjusting a load or when lowering a very short distance.

Illuminating Gas Torch

MARKETING of a gas cutting torch for use with illuminating and by-product gases has recently been announced by The Alexander Milburn Co., 1416-1428 W. Baltimore St., Baltimore, Md.

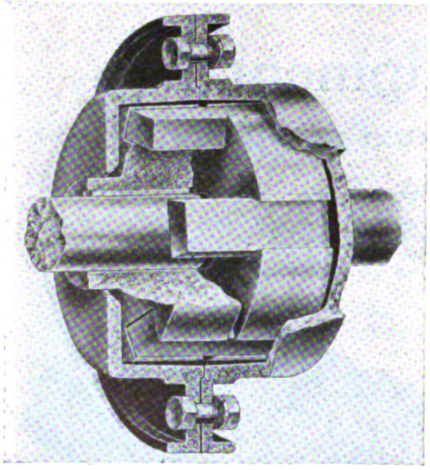
It is claimed that, with city gas costing but one thirtieth as much as other gases, a large saving can be made in fuel gas alone. According to the manufacturers, an outstanding feature of the Milburn Torch is the superheater which heats and expands the cutting oxygen, also the preheating gases, raising the temperature of the cutting oxygen to approximately 100 deg. C. prior to combustion. This increases the temperature of the gases at the torch tip, increases the rate of flame propagation in the burning mixture and, it is stated, reduces the oxygen consumption from 25 per cent upwards. A bunsen burner, contained within the torch, burns illuminating gas which heats the cutting oxygen as it passes through a series of copper coils.

The torch, it is said, is ruggedly constructed of bronze forgings and specially drawn tubing. The high-pressure cutting oxygen is controlled by a thumb valve which remains fixed in either the open or closed position. The torch is 21 in. in length and is supplied with a complete range of tips for light, medium and heavy cutting.

Metallic Flexible Coupling

A NEW design of flexible coupling, shown in an accompanying illustration, is announced by W. H. Nicholson & Co., Wilkes-Barre, Pa., manufacturers of the Nicholson compression coupling. It is a metallic coupling throughout, and does not have any springs, laminated bolts, grids, gears, or disks. The coupling consists of two flanges or hubs, with slotted rims, which are keyed to the shaft, a two-piece shell, and three or five tapered keys to fit into the slots as shown.

The operation as described by the manufacturer is as follows: Shaft misalignments are taken care of by means of the loose-fitting, floating keys, with beveled sides. In the small sizes of couplings three floating keys are used, and on larger sizes, five. When in motion centrifugal force throws the floating keys out into the slots, which, it is stated, causes them to drive quietly



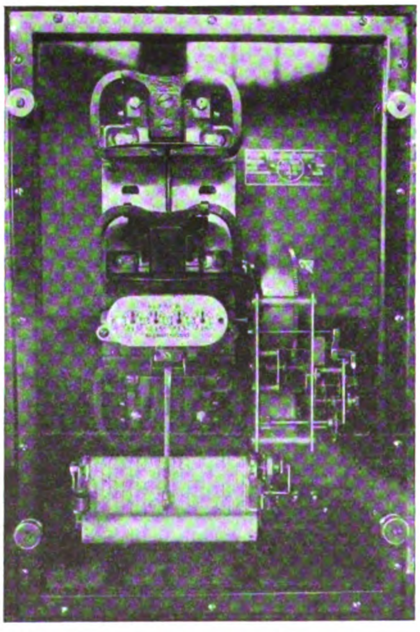
Nicholson all-metal coupling.

and smoothly. When the torsional load comes on, the centrifugal force acting on the floating keys is overcome and they recede to the bottom of the slots. The interior of the coupling is filled with oil. A film of oil is maintained between the keys and slots at all times, allowing a free lateral float of the coupling hubs. This coupling, which is made for all sizes of shafts and all conditions of service, is described more fully in Bulletin 1026 issued by this company.

Three-Phase Four-Wire Watt-Hour Meter

AS A result of increasing demands and changing conditions, some electric service companies are changing many of their circuits from three-phase three-wire, or two-phase three-wire to three-phase four-wire.

Up to this time the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., has furnished three-element meters in the standard OA house and switchboard types. Now a



Westinghouse new three-phase four-wire watt-hour meter.

line of three-element RA demand meters has been added to the OA design, making a complete line of three-element meters to meet the requirements of the central station.

The new meters are similar to the standard RA and OA house and switchboard type meters, differing from them only in that they possess an additional metering element and disk. All of the desirable qualities of the two-element meters are said to be retained in the new product.

Force Feed Lubricating System

ANNOUNCEMENT is made by the manufacturer, Farmer Lubrication Systems, Inc., 2611 Sixteenth Street, Detroit, Mich., of the adaptation of the Farmer Lubricator, which was designed for "one shot" automobile lubrication, to industrial applications. This lubricator consists of a reservoir, the large units of which, it is stated, will hold enough heavy oil, 600-W, to lubricate 30 to 40 bearings for three months. A ball check valve is located at the bottom of the reservoir to prevent the return of the oil to the reservoir as pressure is applied. Oil passes from the reservoir through this check valve into the compression chamber and is forced to the various bearings by this compressor through pipes leading from the compression chamber to them.

Pressure can be applied by hand or foot pressure plungers on the small units or by a screw and handwheel on the piston in the compression chamber of the larger units. The pressure is indicated by a gage and it is stated that a pressure of 1,000 lb. per sq.in. may be applied. The valve of each bearing is designed to supply a fixed amount of oil to the bearing at each "shot," it is stated, and will shut off automatically when the bearing is supplied, irrespective of the amount of pressure in the compression chamber; that is, the valve at the bearing is opened as the pressure is built up and closes as the valve empties. These valves at the bearings can be regulated to supply different quantities of oil.

Air Filter

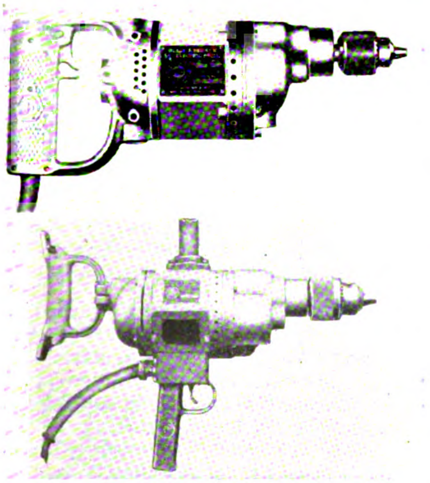
A NEW air filter which the manufacturer states has a number of outstanding advantages has been developed by the American Blower Company, Detroit. By means of this new filter, which is of dry plate design with hair-like tentacles for the arresting and retention of dust and dirt, dust-laden air is divided into a series of small jets which strike the flat filament-coated surface of the plates, dust and soot being projected against the filament, seized and retained. The air, changing its direction and rebounding from this surface, flows through to the next plate and is carried through ten successive dust-removal operations of this type. As dust builds up on these flat surfaces each preceding layer acts as a retentive member, the dust first attracted being itself the principal arresting and retaining factor for the succeeding particles. In this way the use of ad-

hesives is avoided and the maximum load of a cleaner or filter is multiplied.

The outstanding advantages of this type of air filter are said by the manufacturer to be that it is impossible to clog the filter, that it does not require oil or other adhesives which have to be changed from time to time, that it has a constant effect and constant efficiency and that dust builds up on dust and does not get in the line of air flow.

Two New Electric Drills

IMPROVEMENTS on the ¼-in. standard ball bearing electric drill have been announced by The Black & Decker Mfg. Co., Towson, Md. This drill, shown at the top in the accompanying illustration, is intended to replace the light ¼-in. drill made by this company. The new drill is provided with an improved universal motor that drives the



Two new Black & Decker electric drills.

chuck through a double reduction gear unit at a no-load chuck speed of 2,000 r.p.m. All rotating shafts are mounted upon ball bearings. The tool is capable of drilling holes up to ¼ in. in diameter in steel, it is said, and weighs 6 lb.

The lower drill of the two shown is the new ⅝-in. portable electric drill. This drill is designed to drill holes up to ⅝ in. in steel or up to 2 in. in wood. A universal motor, wound with special characteristics for this type of service, is used. Normal open-type ball bearings are used on the armature shaft.

Universal Electric Hoist

UNIVERSAL electric hoists which may be operated interchangeably on direct current or single-phase alternating current of 110 or 220 volts have been placed on the market by Louis E. Emerman & Co., 1761 Elston Ave., Chicago, Ill. This hoist has a minimum headroom of only 11 in., weighs 95 lb. complete, and is built in 500-, 1,000- and 2,000-lb. capacities. The hoist is provided with 12 ft. of load chain and a hook. The hoist unit is shown in the accompanying illustration.

It is stated that the hoist may be operated from any power socket and that a limit stop, which operates with

Universal electric hoist manufactured by Louis E. Emerman & Co.

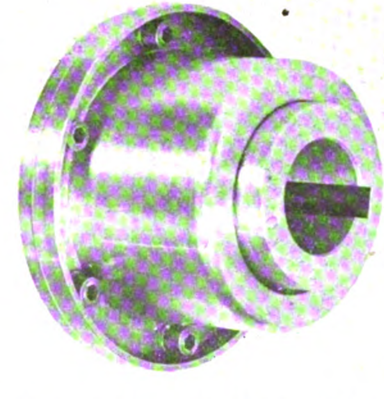
the hook at either end of the chain, shuts off the current when the hook has reached the upper limit of travel. It is also stated that this hoist does not need any holding or lowering brakes and, consequently, hooks may be placed on either or both ends of the chain. According to the manufacturer the full-load lifting speeds for the hoists of the different ratings are as follows: 500-lb. hoist, 28 f.p.m.; 1,000-lb., 12 f.p.m.; 2,000-lb., 6 f.p.m. These units are built for hook suspension or I-beam trolley.

Flexible Couplings

THE new Falk flexible coupling, which is now being marketed by the Falk Corporation, Milwaukee, Wis., has been designed to insure equipment that is directly connected through it against the hazards of all ordinary misalignment.

This coupling consists of two flanged steel disks provided with slots into which is fitted a tempered steel spring formed into a series of hairpin loops, which connects the disks and is the medium through which power is transmitted from one unit to the other. The disks are enclosed in a shell which protects the coupling parts from dirt, acts as a simple fastener for the spring, and as a container for lubricant.

It is said that these couplings are



New design of Falk flexible coupling.

precision-made to fine limits, and that their construction provides for disconnecting the coupled shafts, without disturbing either machine. Also, alignment is reduced to the simplest operation, requiring only a short straight-edge and an ordinary set of feelers. These couplings are made in sizes from ⅓-hp. to 20,000-hp. capacity at 100 r.p.m.

Insulation Resistance Meter

THE megohm insulation meter shown in the illustration has recently been placed on the market by The Martindale Electric Co., Cleveland, Ohio. This meter weighs only 11 lb. and the readings obtained in testing equipment are said to be independent of the speed at which the generator in the meter is driven. The scale of the instrument, which is graduated to read

Martindale megohm insulation resistance meter.

directly in ohms or megohms, has a range from 200 ohms to 100 megohms. It is claimed that readings can be obtained instantaneously.

Heavy-Duty Meter Element

A NEW, heavy-duty meter element for use in direct-current ammeters, direct-current voltmeters and speed recorders where heavy damping is required has recently been placed on the market by The Esterline-Angus Co., Indianapolis, Ind.

The mechanical construction of this element is similar to that in the standard meter elements, but the magnetic circuit is made stronger, so that the magnetic field in which the coil moves is very intense. This increases both the torque and the damping effect. Increase in torque makes it possible to furnish direct-current ammeters which will give full scale deflection on 75 millivolts, and they can be furnished for operation on shunts of either 75 or 100 millivolt drop. The damping effect is said to be such that current sufficient to bring the instrument to full scale can be applied instantaneously, without causing the instrument to overshoot.

Trade Literature
you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Voltage-Regulator — Catalogue S.P.-1734 describes and illustrates the application of various types of regulators for the control of generator voltage.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Non-Breakable Socket — A circular describes the K-28 series composition socket of the bayonet type which, it is stated, is molded of a composition not easily broken.—Line Material Co., South Milwaukee, Wis.

Motors and Fans—"The Emerson Monthly" discusses various applications of Emerson motors and fans for industrial and other purposes.—The Emerson Electric Mfg. Co., 2012-32 Washington Ave., St. Louis, Mo.

Safety Switches—Catalog No. 32 describes and illustrates various types of safety switches, and the tables which accompany the illustrations give prices, sizes and other data.—Square D Co., Detroit, Mich.

Lamp Reflectors—The Durex type of reflector and canopy can be had in several different styles which are described and illustrated in a new pamphlet.—Wheeler Reflector Co., 275 Congress St., Boston, Mass.

Portable Elevators—Bulletin No. 90A describes and illustrates a hand-power type of portable elevator that embodies a revolving base feature.—Revolvator Co., 336-352 Garfield Ave., Jersey City, N. J.

Electric Hand Saw—The Wodack hand saw is described and some of the various uses to which it can be applied are illustrated in a four-page circular. —Wodack Electric Tool Corp., 23-27 S. Jefferson St., Chicago, Ill.

Head and Eye Protective Devices.—Many different types of devices which are designed to protect the eyes and head while welding, grinding, chipping, and similar operations are being performed, are described and illustrated in Catalog No. 26.—American Optical Co., 70 W. 40th St., New York, N. Y.

Loose Pulley Oiler—A circular describes the Gast Oiling Machine for loose pulleys, which is designed to be attached to any loose pulley. This device consists of an oil chamber, a chain oiler, and a bushing which fits into the pulley.—Standard Pressed Steel Co., Jenkintown, Pa.

Transformer Oil Purifier—The No. 600 transformer oil purifier, portable type, is illustrated and described in a leaflet.—The De Laval Separator Co., 165 Broadway, New York, N. Y.

Centrifugal Clutches—Various applications of the Broadbent centrifugal clutch are illustrated in a leaflet. A new 40-page catalog contains very complete information relating to the application of these clutches to electric drives.—T. V. Cotter & Sons, 859 Broadway, S. Boston, Mass.

Tractors—Bulletin No. 106 describes and illustrates the Mercury Type H electric tractor. Bulletin A-25 discusses the Type A-510 heavy-duty trailer. —Mercury Manufacturing Co., 4118 S. Halsted St., Chicago, Ill.

Hydraulic Presses—A new quarterly publication "The Hydraulic Press" describes and illustrates various types of hydraulic presses and discusses applications.—The Hydraulic Press Mfg. Co., 20 E. Broad, Columbus, Ohio.

Overhead Carriers—A pamphlet, illustrating and describing some of the advantages of the Cleveland Tramrail Systems as applied to moving material about a factory, is now available.—The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Transformers — Bulletin 232 illustrates the various types of Moloney transformers and shows applications. —Moloney Electric Co., St. Louis, Mo.

Aluminum Conduit Fittings.—Catalog 5 covers the Veco line of vapor-proof junction boxes and other fittings manufactured from a special aluminum alloy.—The Veco Mfg. Co., South Norwalk, Conn.

Rolling Doors—A 32-page catalog illustrates by photographs and sketches various types of steel rolling shutters and doors and Underwriters' labeled rolling fire doors and shutters.—Cornell Iron Works, 36-20 Thirteenth St., Long Island City, N. Y.

Special Machinery—A 38-page catalog describes the line of Schultz winches, hoisting crabs, clutches, gears and sprockets, and special machinery. —A. L. Schultz & Son, 1675 Elston Ave., Chicago, Ill.

Underground Distribution—A circular illustrates and describes some of the various high- and low-voltage underground cable distribution boxes manufactured by this company.—G & W Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Electric Drill—A circular describes the 25-B Little Giant universal ¼-in. electric drill, the 252 Little Giant universal electric screw driver and nut runner, and the 250-M Little Giant universal electric tapper.—Chicago Pneumatic Tool Co., 6 E. Forty-fourth St., New York, N. Y.

Flexible Shafts—Booklet B shows the various types of Strand flexible shafts and their application to equipment for grinding, drilling and other similar services.—N. A. Strand & Co., 5001-5009 N. Lincoln St., Chicago, Ill.

Spray Cooling Systems—A book entitled "Spray Cooling Systems" gives interesting data on the operation of cooling systems for cooling, condensing and circulating water.—Binks Spray Equipment Co., 3114 Carroll Ave., Chicago, Ill.

Distribution Transformers—Westinghouse Type SK steel-clad distribution transformers are described in detail together with the outstanding features of their application and construction, in leaflet 20,133-A.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Force-Feed Lubricators—A general catalog describes the various types of centrally-controlled, force-feed oiling systems for industrial and power-plant machinery.—Hills-McCanna Co., 2025 Elston Ave., Chicago, Ill.

Entrance Switches—Catalog 20 describes the Wadsworth line of meter service and main entrance switches in which the main or service fuses are accessible only when the switch is open and the fuses are dead.—The Wadsworth Electric Mfg. Co., Covington, Ky.

Arc Welder—A circular describes the Hansen arc-welding generator which, it is stated, needs no external stabilizing device to assist the operator to strike and maintain the arc. This condition is obtained by a novel position of the commutating pole winding.—Northwestern Mfg. Co., Milwaukee, Wis.

Hoists and Cranes—Catalog 11 is a 72-page handbook on chain hoists, trollays, hand cranes and allied equipment. It contains illustrations and general descriptive matter, as well as line drawings giving all dimensions and the required clearances of the various types. —Wright Mfg. Co., Lisbon, Ohio.

Pneumatic Tools—A 60-page catalog describes the O line of Super-Pneumatic tools, such as high- and low-speed drills, reversible slow-speed drills, grinders, and a saw attachment.—William H. Keller, Inc., Grand Haven, Mich.

Ball-Bearing Motors — A 32-page booklet entitled, "Better Motors with Fafnir Ball Bearings," discusses the operating economies, such as reduced maintenance and repair cost, together with other advantages, which it is stated, result from the use of ball bearings in motors.—The Fafnir Bearing Co., New Britain, Conn.

Mica and Mica Products—A catalog bearing the above title contains much information about the use of these materials for electrical insulation—William Brand & Co., 27 E. Twenty-second St., New York, N. Y.

Rebuilt Electrical Equipment—Frequent bulletins list the various units of new and rebuilt electrical equipment for sale by this company.—Fuerst-Freidman Co., 1292 E. Fifty-third St., Cleveland, Ohio.

Volume 85 New York, February, 1927 *Number* 2

G. A. VAN BRUNT
Editor
D. H. BRAYMER
Consulting Editor

INDUSTRIAL ENGINEER

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

A. J. WHITCOMB
Contributing Editor
F. E. GOODING
G. H. FAIRBANKS
Associate Editors

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Contents

Departments

What You Will Find In This Issue

CAREFUL maintenance of equipment with close control of costs is something that interests every industrial executive. Thomas W. Suddard, Secretary, The Hamilton Manufacturing Co., tells on page 45 how these objectives can be attained.

Those who would like to know how other operating men handle the problem of when to replace equipment should read the article on page 51. The discussion on this important question may give some new viewpoints.

How maintenance procedure can be effectively organized on the scale required in the South Bend, Ind., plants of The Studebaker Corporation is told on page 58 by Ira De Moss, General Foreman of Maintenance.

Keeping storage battery trucks and tractors in continuous service under very severe operating conditions is one of the problems of W. Landess, Chief Electrician, The Chicago Union Station Co. On page 63 he describes the methods that he has found effective in doing this.

Then, in a symposium article beginning on page 66, O. C. Callow, Chief Electrician, Trumbull Cliffs Furnace Co., A. L. Bingham, and J. Elmer Housley, Electrical Engineer, Aluminum Company of America, tell how they have reduced operating and maintenance costs.

Those who are interested in the layout of electrical repair shops will find the article on page 72 by H. E. Van Alstyne, Superintendent, Miller-Seldon Electric Co., full of helpful suggestions.

Painting of plant buildings presents a number of problems that are discussed in the article on page 78.

Following these articles there are four departments full of practical suggestions on the solution of plant operating problems.

Finally, several pages are devoted to a description of new equipment that has been designed to cut operating costs and improve plant operating conditions.

In the advertising pages there is a wealth of information on equipment that will help to solve operating problems. Here, too, are suggested forms for Summary Sheets that will make it easy to keep track of the condition of plant equipment.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

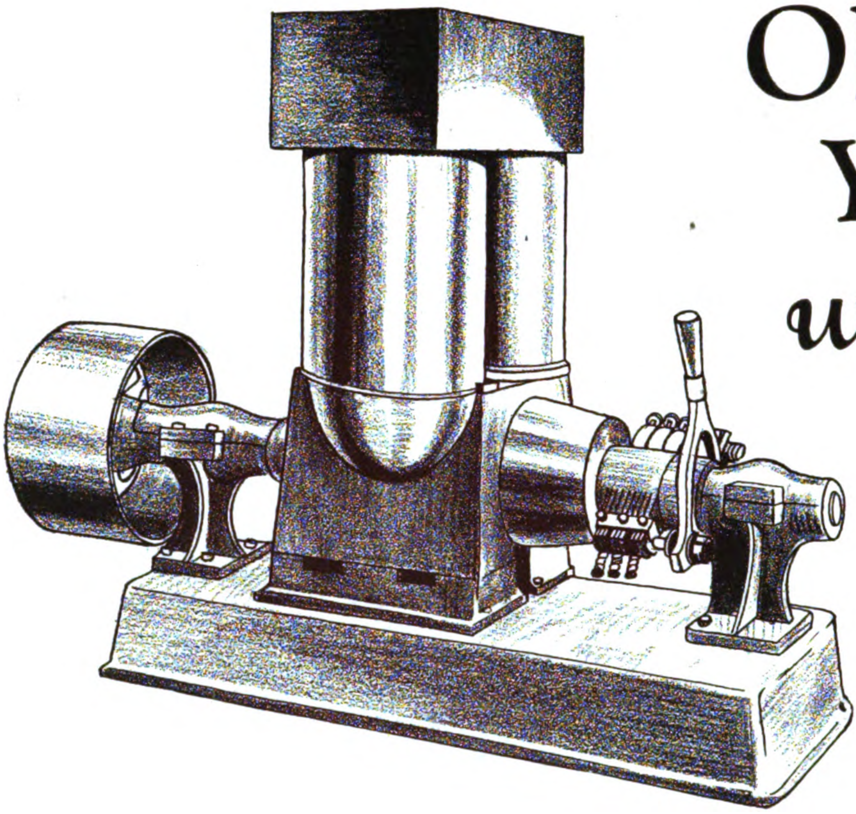
WASHINGTON, Colorado Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4

Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record
American Machinist
Power
Chemical and Metallurgical Engineering
Coal Age
Engineering and Mining Journal
Ingeniería Internacional
Successful Methods
Bus Transportation
Electric Railway Journal
Electrical World
Electrical Merchandising
Industrial Engineer
Radio Retailing
Electrical West
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Parguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.



Obsolete—
Yet not worn out

Probably none of the old Edison Generators of the type above illustrated ever wore out—nothing much about them to wear—yet you never see one in commercial use today.

Why?—because the science of building generators developed so rapidly that it was economy to scrap the old and install the new.

The same is true of brushes. We heard the other day of a set of brushes which had been on one machine continuously for 19 years. That is a tribute to durability. But in 19 years the losses in brushes has been fractionated again and again.

At the least calculation these old brushes were causing 4 Kw. more loss than would modern brushes such as are made by Boxill-Bruel Carbon Co. Four Kw. over 19 years would pay for a good many sets of brushes and still leave a handsome profit.

In economy, efficiency, more satisfactory operation, Boxill-Bruel Brushes have a story for you—write for it.

BOXILL-BRUEL CARBON COMPANY

308 W. 4th ST., CINCINNATI, OHIO

BRANCH OFFICES

New York
507 Fifth Ave.

Pittsburgh
2126 Farmers Bank Bldg.

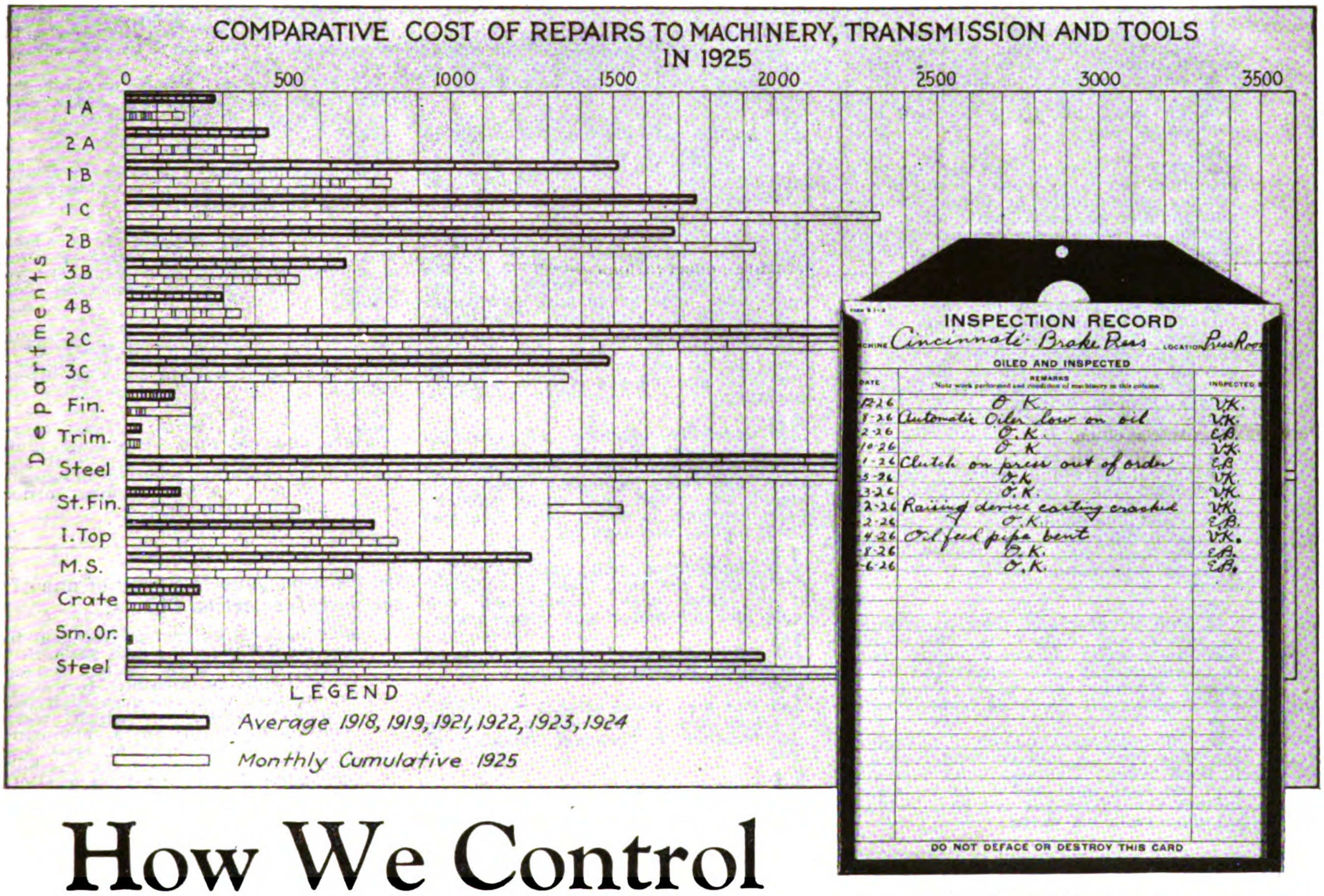
Sheveport, La.
Bennett Sales Co.

Chicago
80 E. Jackson Blvd.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 85 New York, February, 1927 *Number 2*



This chart showing the comparative costs of repairs and the Inspection Record are the two key points in the control of maintenance and repairs and their cost.

At each inspection period the inspector enters the condition of the machine on the Inspection Record. He thus discovers trouble before it becomes serious and keepes the repair costs low. By means of the chart each foreman can see just how his monthly cost record compares with the average performance of previous years.

How We Control Our Maintenance Costs

By THOS. W. SUDDARD

Secretary,
The Hamilton Manufacturing Company, Two Rivers, Wis.

ONE of the very common weak spots in most methods of controlling maintenance and repair costs is that the management either makes a drive to keep everything up in first-class repair and later finds that the cost is too high, which sometimes causes a swing to the other extreme, or it places too much emphasis on a low maintenance cost, which often defeats its own ends because postponed maintenance is always more expensive.

Our plant is no different from others in having to face this problem of reliable maintenance at low cost. However, we believe that we are solving it about as satisfactorily as possible. No plan which depends upon judgment in determining how long a repair can be delayed before it becomes a breakdown can ever be 100 per cent perfect.

The plan in use at the Hamilton Manufacturing Company's plant is based on regular, systematic and thorough inspections of all machinery and equipment, and itemized reports of all maintenance and other costs for every foreman. These costs are also charted and compared with previous costs so that the management can see the trend at a glance. In addition to these, we have various meetings where maintenance and the other plant operating costs are discussed in detail, as will be explained later in the article.

The equipment inspection plan has been in effect about 15 yr. and in general principle and method of

Instructions Accompanying Inspection Chart

THE paragraphs below contain more detailed instructions on the duties connected with the inspection of each type of equipment than could be entered in the "Duties" column in the accompanying Inspection Chart. The numbers in the "Duties" column refer to the corresponding paragraph numbers below.

1 Run pump with discharge open to atmosphere until water is lifted and passed through. This will keep valves free and in working condition. While pump is moving pass cylinder oil through lubricator freely and oil outside parts.

2 This pump to receive regular daily attention, but every week the number of strokes per minute in actual service, and number of s.p.m. with water discharge valve closed (steam throttle same position) shall be recorded on inspection sheet.

3 The sprinkler systems are to receive same general attention as at present. Special inspection to be made and gage pressures indicated must be entered on inspection sheets. All alarms to be tested and annunciator drops in Power Houses observed. If not in proper working order report to Master Mechanic's office.

4 Oil all parts and carefully examine lubrication inside of worm-gear box. Inspect all safety appliances, cables, gates, and overhead sheaves. Also, all belting driving the machine and supporting bolts and nuts, both on the hoisting apparatus and on overhead work.

5 Run elevator and observe condition of motor and controller. Make immediate repairs, however small. See to lubrication of all bearings and worm gear. Examine all safety appliances and see that all overhead work is safe.

6 Oil bearings, and on d.c. motors see that brushes and commutators are in good order. Examine belts carefully and see that nuts and bolts by which motors are suspended are tight. Wipe all dust from all parts.

7 Blow dust from windings with compressed air and wipe clean. This means that motors and compensators shall be well kept so far as cleanliness is concerned.

8 Change valves from live steam to exhaust steam 7 a.m. and reverse at 6 p.m., during heating period of year; valves located: ...., Wind thermostats twice each day; located: ....

9 During time of year when outside temperature is 40 deg. F. or less, temperature observations shall be made twice in forenoon and twice in afternoon; also, once at 10 p.m. and again at 4 a.m. by the night man. The water shall never be allowed to get colder than 40 deg. F. Each time heating steam is turned on engineer shall go into tank pit and see if it is properly operating.

10 Carefully examine all bearings and drive belt. See that oil in crank case is of proper height. Change oil in crank case every 90 days. When oil is tapped off, wash out with kerosene before putting in fresh oil. Requires 5 gal. to fill; use auto oil.

11 Steam-fitter will examine oiling devices and see that there is sufficient oil in crank case. Electrician will clean and oil motor and compensator.

12 Oil and repair. The record is in the Master Mechanic's office.

13 Put 1 pt. wood alcohol into feeder at 8 a.m. and 3 p.m. each day during cold weather to prevent freezing of pipes.

14 Examine belt carefully for open laps and make immediate repairs if any are found.

15 Examine general condition of bulkhead at river front and suction well.

16 Inspect pump and motor twice each day when in operation and keep well cleaned and oiled.

17 Inspect each morning during heating season and see that traps are in working order; location of traps: ....

18 Make general inspection and see that traps are in working order and not blowing through; location of traps: ....

19 Examine every firedoor in plant and see that they are in working order and not obstructed.

20 See that all firepails are in place and filled; also, that water is not stagnant. See that hose connected to sprinkler risers is in good working condition.

21 Make complete tour of entire plant and observe general condition of machinery. Collect written notes of observations.

22 Inspect all valves, piping, thermostats and controls. Interview man in charge to get complaints and information regarding behavior of apparatus. When not in working order notify master mechanic.

On the next page is a copy of one of the early Inspection Charts.

Because of extensive changes in the plant during the past year, this chart would have to be revised considerably at present. However, it, together with the accompanying instructions, all of which were originally placed on a blueprint but are shown here in type for easy reading, indicate the method of approach for installing a similar system which, of course, would have to be worked out for the particular plant problems involved.

application is practically the same as when inaugurated. Previous to that time the plant had been operating on the plan of doing maintenance when it was found necessary, but seldom found it until a breakdown occurred. Breakdowns interfere with production and are much more costly than if the cause had been remedied earlier.

Our Mechanical Superintendent at that time, who had to bear much of the trouble caused by these breakdowns and was devoting considerable attention towards devising a plan to anticipate and so prevent much of the trouble, noticed the stenciled notation, "Inspected" which was followed by the date, on the air-brake cylinder of a freight car. He had seen this many times before, but this time he got the idea of applying a similar method of systematic inspection to the machinery and equipment in the plant.

Instead of stenciling the date of the inspection on the machine, however, an Inspection Record card is used. One of these cards, a filled-in sample of which is shown at the top of page 47, is used for each machine. At first all cards were placed in the metal card holder and the surface protected with a sheet of celluloid. This protection has been discarded as unnecessary except in the dirtier locations. The card is hung on the wall or on a column near the machine. The machinist who makes the inspection notes the date and anything he finds wrong, or adds his OK, and enters his initials in the last column.

Whenever anything is found which is likely to cause trouble, the inspector reports it to the foreman and a Maintenance Shop Order is issued at once. If the foreman does not issue an order to have the trouble corrected, the inspector reports it to his superior. However, the foremen are so thoroughly sold on the reduction in maintenance and repair costs which results from remedying any minor defect before it causes real trouble that a refusal is practically unknown.

Many of the troubles which show up should have been reported by the operator to his foreman. However, men experienced in plant operation know that the operator will seldom complain about the machine as long as it will get out the scheduled production. A bent oil pipe means nothing to him, at least until it clogs up. Usually, however, by that time a bearing must be replaced also. The increased cost, due to the renewal of the bearing, would probably amount to several times as much as the inspections cost for the year.

The cost of these inspections is charged to the department according to the time spent in that department

INSPECTION CHART

MACHINE	LOCATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	DUTIES
Fire Pump	Old Power H'se.	O		O		O		O		O		O		O		O		O		O		O		O		O		O		O		O	1
General Service Pump	Old Power H'se.	O						O						O						O						O						O	2
Sprinkler Risers	Entire Plant	S							S							S							S							S			3
Belt-Driven Elevators	Entire Plant		S							S							S							S							S		4
Electric Elevators	Warehouse		S	E						S	E						S	E						S	E						S	E	5
Power Motors	Entire Plant	E							E							E							E							E			6
Power Motors	Entire Plant	E														E																	7
Steam Heating	Entire Plant	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	8
Sprinkler Tank	Next to Office	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	9
Air Compressor	1st. Steel		S				S				S				S				S				S				S				S		10
Air Compressor	4th. Wareh'se.		S				S				S				S				S				S				S				S		11
Portable Electric Drills	Steel Plant	E							E							E							E							E			12
Alcohol Feeder	2nd. Steel	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	13
Main belt, Engine	New Power H'se.	B		B		B		B		B		B		B		B		B		B		B		B		B		B		B			14
Main belt, Generator	New Power H'se.	B		B		B		B		B		B		B		B		B		B		B		B		B		B		B			14
Intake from River	Lumber Yard	O						O						O						O						O							15
Johnson Pump	Office Basem't.	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	16
Main Belt of Engine	Old Power H'se.		B				B				B				B				B				B				B				B		14
Low-Pressure Traps	Entire Plant		S							S							S							S							S		17 *
High-Pressure Traps	Entire Plant		S				S				S			S				S				S					S						18
Fire Doors	Entire Plant				W							W							W							W							19
Fire Pails and Hose	Entire Plant				W							W							W							W							20
Plant Inspection	Entire Plant															X																	21
Lumber Dry Kilns	Entire Plant					S							S							S						S							22
Steel Enamel Ovens	3rd. Steel					S							S							S						S							22
Wood Enamel Ovens	4th Wareh'se.					S							S							S						S							22
Air Brush Equipment	4th. Wareh'se.										S														S								23
Air Brush Equipment	3rd. Steel										S														S								23
Dictaphones	Main Office		M							M							M							M						M			24
Roofs and Downspouts	Entire Plant															**X**																	25
Time Clocks	Entire Plant															**M**																**M**	26
Time Clocks	Entire Plant		**M**							**M**							**M**							**M**						**M**			27
Double Spindle Shapers	Entire Plant															W																	28
Gates, on Elevators & Tramways	Entire Plant				W							W							W							W							29

– SYMBOLS –

Master Mechanic	**X**
Ass't. Master Mechanic	X
Engineer Old Power House	O
Engineer New Power House	N
Electrician	E
Steam Fitter	S
Millwright	W
Machinist	M
Machinist Apprentice	**M**
Belt Repair Man	B

Note:– The numbers in the column under "Duties" refer to a particular paragraph in the accompanying list of Instructions

23 Examine general conditions and have needed repairs made at once. These devices must be kept in the best of condition and no time must be lost in putting apparatus in good working shape. The productive capacity demands it.

24 Examine all dictaphones, oil same, wipe all parts clean. See that cylinder-shaving machine in basement is in working order.

25 Make inspection of all roofs and report to master mechanic.

26 Reset time clocks for dates.

27 Wind time clocks and set same. Report trouble.

28 Have an order entered in master mechanic's office and quarter-turn bearings on double-spindle shapers; location: ....

29 Examine all gates on elevators and tramways. See that gates are free in their slides and ropes in good condition.

NOTE: * When inspection discloses apparatus out of order it must be reported to Mechanical Superintendent's office at once; the person making such report can prove himself blameless only by personally witnessing the making out of a Maintenance Shop Order for execution of work reported. In case the date indicated falls on Sunday or a holiday, the work must be performed on previous day. The yellow Inspection Record located at the machine must show your signature and date in order to prove that you or your substitute executed the work as above. These Inspection Records must be hung in conspicuous locations and kept up to date. Remember that your work is watched by officials at the Inspection Record.

MECHANICAL SUPERINTENDENT.

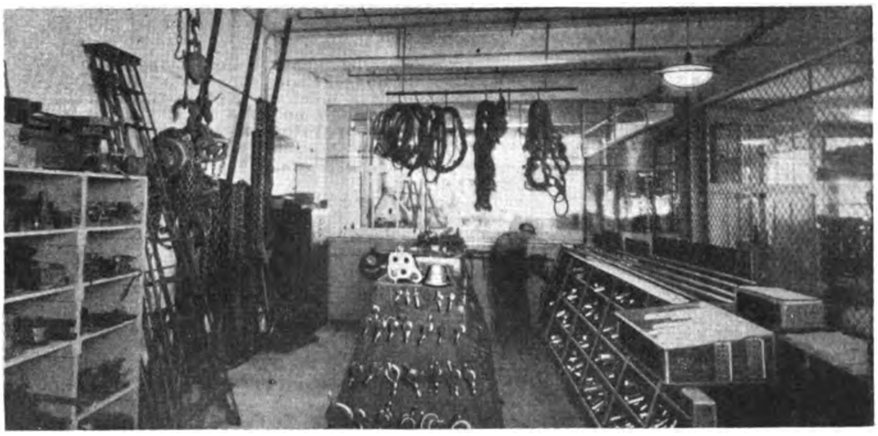
by the inspector as shown by his time card. Nothing can be saved by using a low-grade inspector. The best machinist in the entire plant makes the inspections on the higher-grade and more complicated machinery. We are engaged in the production of wood and steel furniture for printers, dentists, and drafting rooms and so have a number of large woodworking and metalworking machines which we cannot afford to take out of service for expensive repairs, in view of the consequent interruption of production.

When this plan was first inaugurated, our Mechanical Superintendent prepared a detailed Inspection Chart with instructions on the inspection of each type of equipment. When first installed, the men frequently consulted the chart, but as they soon became familiar with it, they had little occasion to use it. In a plant like this, which is the main industrial establishment of a small town, the personnel does not change nearly as much as in many other plants.

Under present conditions, this chart would require a very thorough revision because of the recent growth of the plant and the extensive rearrangement of the equipment which has taken place during the past summer. The Inspection Chart and the Instructions, which are reproduced here, are taken from one of the early charts and are considerably out of date, particularly as to the location of the machines and in some cases as to the time between the inspections. However, the same principles and methods shown here are still followed. Probably no other plant could copy this chart as it is and expect to use it without modifying it to fit particular needs.

This inspection routing had immediate results in decreased repair costs and in keeping the equipment in condition. However, I believe that every line of industrial activity should be closely co-ordinated with the cost and will benefit by having the foremen know the cost of everything for which they are responsible, particularly those items which are indirect expenses, such as maintenance and repair, miscellaneous supplies, and so on. To this end, we added, to the inspection routine, a maintenance and repair cost record and method of distributing these costs to our foremen. Shortly after the end of the month, each foreman receives an itemized statement of all such expenses for his department for the previous month. This report is discussed both in private, if desired, and in the general meetings, which I will cover later.

All orders for any maintenance repairs are made out on the Maintenance Shop Order shown in *A* in



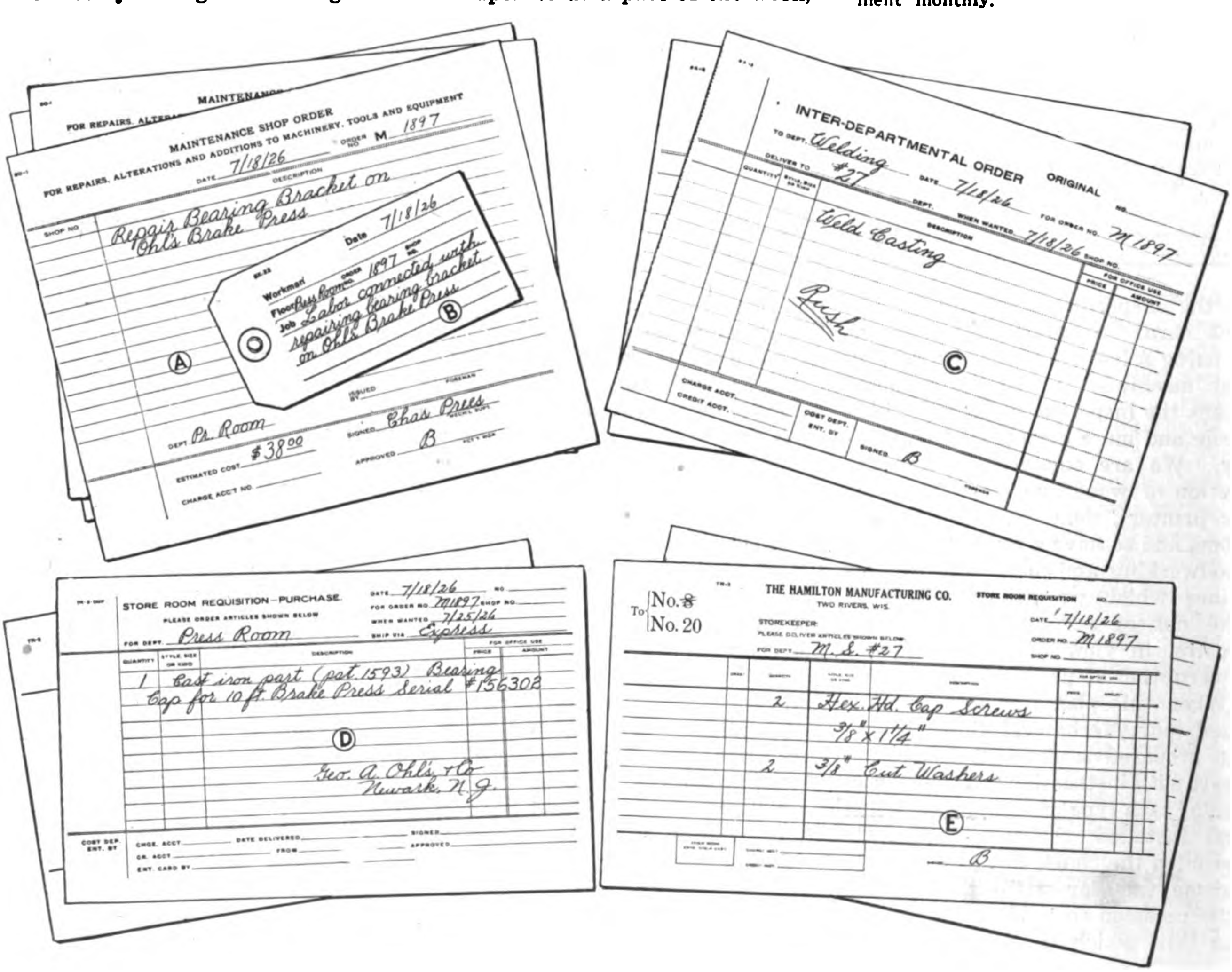
A view of the stock- and toolroom taken from the foreman's office.

This room is in the center of the side wall of the building and contains not only the tools for the machine shop, but also ladders, hoists, cables, portable electric tools and other misceellaneous equipment used by millwrights and repair men. All equipment or supplies are issued on tool check or requisition.

the accompanying set of forms. This order is used for all repairs, alterations and additions to machinery, tools and equipment. The order is issued by the foreman and must be OK'd by the mechanical superintendent and, if for a large amount, by the factory manager. An original and a duplicate are issued on this; the back of the duplicate shows the costs and is returned to the Cost Department when the job is finished.

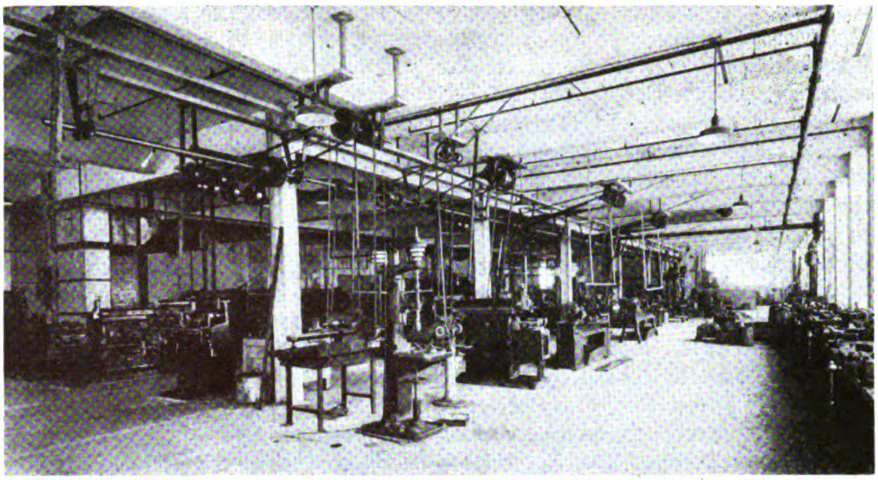
From the data on this order the mechanical superintendent makes out for each job another order on a manila tag, *B*, which gives the order number and other necessary information to the workmen. When this tag is returned, the mechanical superintendent knows that the job is finished and he can then notify the Cost Department that the job is completed.

Sometimes another department is called upon to do a part of the work, as in the case of repairs to the bearing bracket on the brake press, which was discovered on August 2, as shown by the Inspection Record on page 45. It was decided to weld the casting and so Interdepartmental Order *C* was issued for this welding. If it had been necessary to purchase a new casting, an Order for the Purchasing Department, *D*, would have been issued. Miscella-



The five record forms used in handling maintenance work.

Whenever any alterations or repairs are to be made, on tools or equipment, the foreman issues a requisition on the Maintenance Shop Order *A*. The triplicate goes to the Cost Department and all material and work charged against this order number are entered on the back. When this Maintenance Shop Order is received, the Mechanical Department fills out the Work Tag *B*, which is given to the repair man, who returns it to the office when the job is finished. The Mechanical Department then informs the Cost Department that the job is completed. Occasionally, it is necessary to have some work performed by one or the other production departments and then an Interdepartmental Order, *C*, is filled out, as for this welding job. Where material must be purchased for a job an Order on Purchasing Department, *D*, is issued. Materials are drawn from stores by the Store Room Requisition, *E*. The job order number against which all these materials and labor are to be charged enables the Cost Department to figure the cost of each job, and an itemized report of these are given to the foreman of each department monthly.



A view of the Mechanical Department repair shops.

The maintenance departments have just moved into a new building and occupy the entire end of the first floor. The machine shop is in the foreground, the electrical repair department at the extreme end of the aisle, the blacksmith shop is located in the other corner of the extreme end of the building and the foreman's office and stock- and toolroom located at the center of the right-hand wall. The space between the blacksmith shop and the electrical repair shop is devoted to pipe and conduit fitting and similar work.

neous supplies, needed for repairs or maintenance, are ordered on *E*, the Storeroom Requisition.

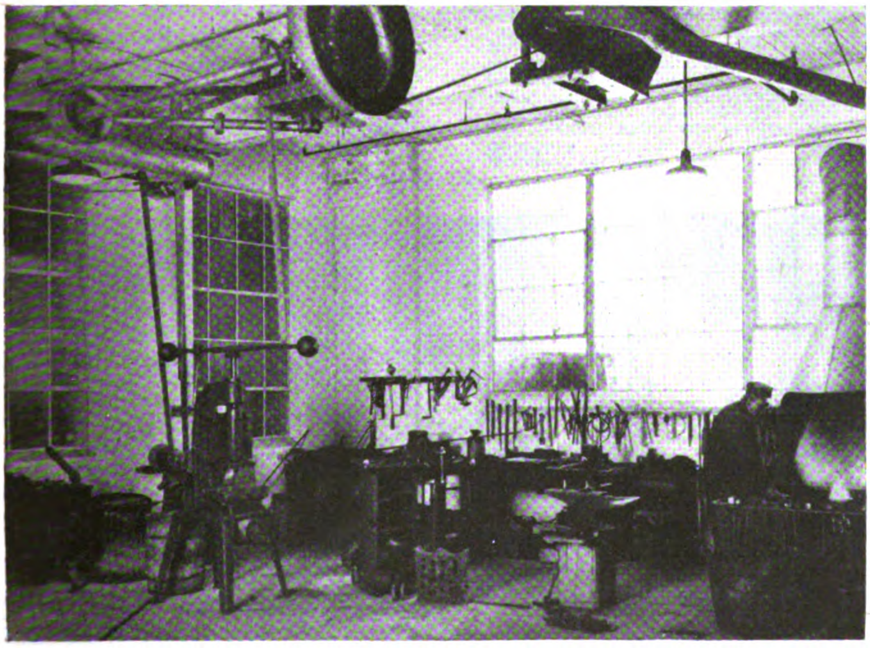
All of these orders carry a job number or some indication to show how the work or supplies are to be charged by the Cost Department. In addition, the monthly itemized list to the foreman reminds him of just what he got; a study of the list indicates ways for him to reduce his departmental costs. He has the Inspection Record against him, however, if he allows needed repairs to go too long and runs up an expensive repair bill. In this way he learns to balance and control his expenditures and costs.

Many interesting cost reductions have resulted from a study of these itemized reports. For example, we had never considered that the use of ball or roller bearings on the lineshafts would be worth our while because the power is all obtained from burning woodwaste and we considered its cost as practically nothing. Under such conditions, what did a few horsepower more or less amount to? However, various foremen began to complain about the high cost of labor and oil for oiling the lineshafts, and point out that ball- or roller-bearing shafthangers would reduce this cost. As a result of our study, we put in SKF ball-bearing hangers, which receive attention only four times a year instead of daily. The savings in labor and lubrication alone are paying for the new hanger bearings.

Another important item is floor repairs. Practically all the buildings have hard maple floors. Most of the wear comes in the trucking aisles, at the doors between departments, and in front of the elevators. The weakest part of the ordinary tongue-and-groove flooring is the upper half of the groove, which splits off as the floor wears. We had been cutting out these worn sections with a portable electric hand saw and renewing them as necessary. Finally one of the men suggested running some maple flooring through one of the machines and removing the tongue and groove before laying in the patch. This worked so well that we endeavored to buy the flooring without the groove and learned of a flooring which is made with a very small triangular projection or tongue on one side and a corresponding small indentation or groove on the other, and we have been using it ever since. As a result, these patches now wear several times as long as they did previously.

To visualize the operating and production costs, we use a number of charts showing the various items of cost, as well as the total, because these can be studied and compared much more easily than can figures. One of these charts, "Comparative Costs of Repairs to Machinery, Transmission and Tools" by departments by months for the year 1925, is reproduced at the head of this article. This chart not only shows the cumulative costs for the year, but also the cumulative average monthly figures from 1918 to 1924, inclusive. Costs for 1920 were omitted from this average because of the abnormal conditions.

This chart is watched closely by all the foremen, and they study carefully the itemized costs to see what items have raised their figure for the month. When a foreman thinks that a repair costs too much, he thrashes it out with the Mechanical Department, which, of course, keeps that department on the alert to see that the items are not so high that they cannot be explained or defended. Also, in several of the departments which have similar equipment, the foremen are direct competitors with each other on low costs. Ordinarily,



One corner of the blacksmith shop.

This contains heat-treating and tempering furnaces, a forge, a grinder, a light hand press, an anvil, benches and a number of miscellaneous tools. In addition, the portable bench vise and stand in the center foreground are often taken to different places in the plant where repairs are necessary.

however, comparisons are made with the cumulative average and the previous average for that particular month, as shown by the chart.

I have made previous reference to the various committees and their part in the control of the shop and the costs. There are six committees in all. The first is a Joint Shop Committee, which is an employee representation organization consisting of seven men elected by the employees and three men appointed by the management. These two groups separately and also jointly discuss general employee and company relations and problems. The Committee acquaints the management with the viewpoint of the employees and in turn conveys to them what the management has in mind.

The next is a Foremen's Committee. This consists of the 30 foremen, the superintendents, assistant superintendents, and the heads of the Mechanical and Power Departments. I preside at this meeting, which is held once a month. All major interdepartmental affairs are discussed and all differences and troubles between the departments taken up and ironed out. It is at this meeting that the cost charts are shown to the men and their explanations of both high and low costs received. This, of course, does not mean that private sessions are never necessary.

Some of the principal problems discussed are: safety, cost per standard hour, cost of defective work, non-productive labor, repair costs, and other costs. Incidentally, the cost of freight and any other item connected with the replacement of any defective work, which may pass the foreman or the inspector, is charged up to the department responsible. When a department is charged with freight to the Coast and back, as one was, it makes that foreman and all the others extra-careful about quality.

In addition, the plans of the company, particularly as to future business prospects, expansion programs, and so on, are discussed with the foremen at these meetings before any public announcements are made, as it makes the foremen feel that they are a part of the company when they know of these plans before the general public hears of them. Confidential matters are also discussed.

These meetings have been held since February, 1920. One example of the results obtained has been the reduction of the reducible overhead (defective work, repairs, store supplies, and so on), which was lowered from 15 cents per man per hour to 9 cents within a year, and to 4½ cents now. This result would hardly have been possible without the itemized expense list which is sent to each foreman, and the monthly foremen's discussion. Without this list, a foreman could not watch his expenses, because he would not know where to direct his attention.

Another example of a saving which has resulted from a study of these items has been the reduction of the benzine consumption in one department from 100 gal. to 20 gal. per day. We had no way of cleaning the dirty benzine, and so the whole tank was emptied each night. The foreman of the department saw that this was one big item of cost, and felt that there should be some way to reduce it. He finally heard of equipment manufactured by S. F. Bowser & Co., Inc., for cleaning and storing benzine. When this equipment was installed the result was a substantial reduction in his costs. The 20 gal. per day represent what might be termed "make-up" benzine.

There are three other smaller committees: Safety, Health and Sanitation, and Fire Protection and Apparatus. The Safety Committee consists of a chairman and three shop men. This committee investigates all accidents immediately after they happen and makes a report. The committee serves 6 mo. and the chairman is a hold-over member of the next committee. This committee also makes an inspection of the plant twice during its 6-mo. term.

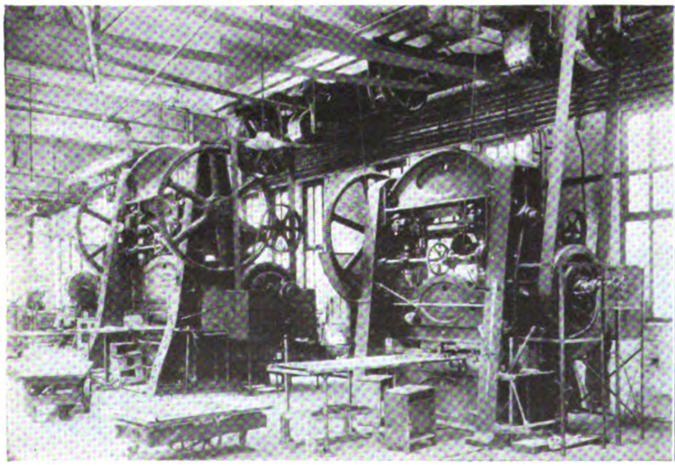
The Health and Sanitation Committee also consists of three men appointed for 6 mo. This committee inspects locker-rooms, washrooms, stairways, toilets, and so on. It also makes two reports during its term. The Committee on Fire Protection and Apparatus inspects all fire apparatus, fireplugs, inspects the hose connections and makes two reports during its 6-mo. term.

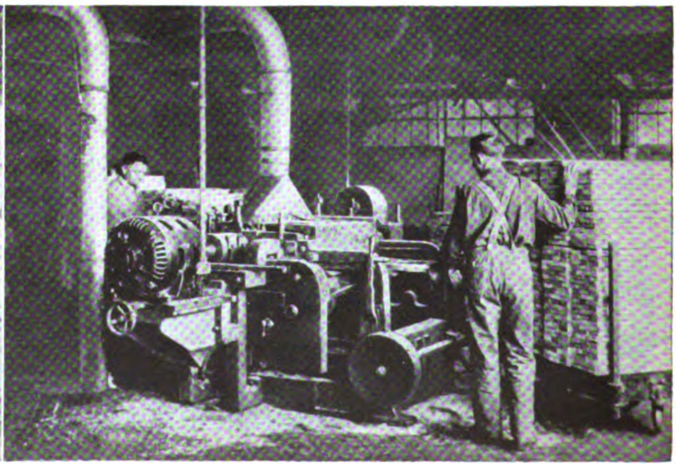
The plan with all of these committees is to rotate the membership and to have as many men serve on them as possible. The chairman in each case is a hold-over member on the next committee, so as to carry forward at least one experienced man on each of them.

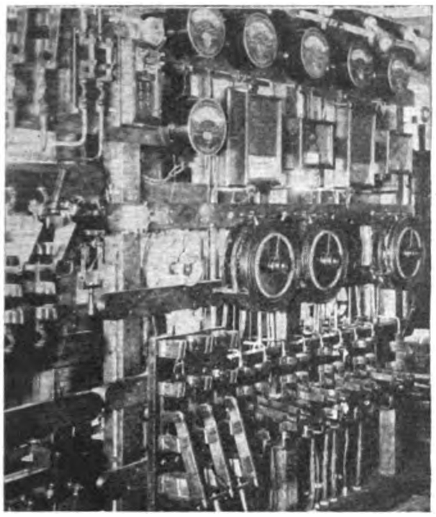
The Manufacturing Board consists of the department heads, the superintendent, the master mechanic, the chief engineer, comptroller, purchasing agent, and secretary. A synopsis of the recommendations made in the reports from all other Committees is received by this Board. This is the controlling committee of manufacturing operations, establishes manufacturing policies, and makes recommendations to the Board of Directors.

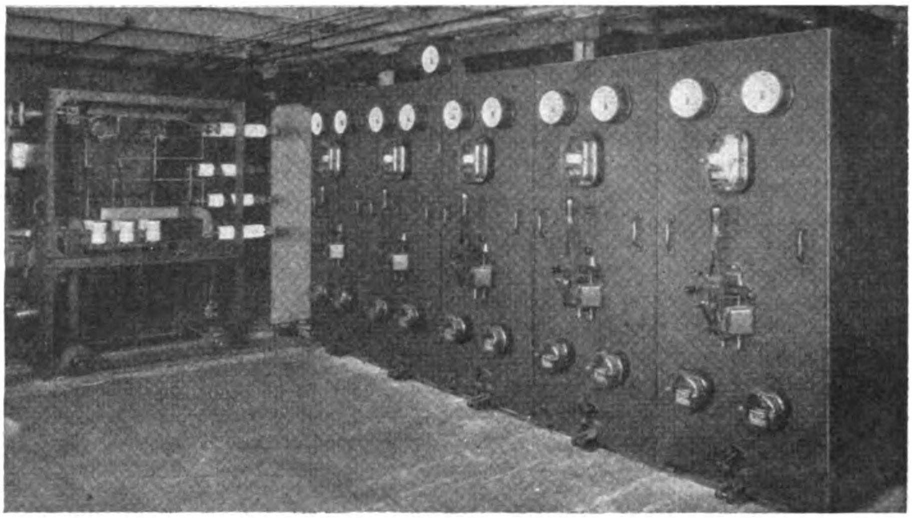
Two typical machine installations in the plant of the Hamilton Manufacturing Company.

This plant is engaged in the manufacture of both wood and metal printers', dentists' and drafting room furniture. It is the careful inspection of such machines as this that not only keeps the cost of repairs and maintenance down, but also adds to the safety of the workers. The inspector exercises particular care to detect hot bearings, slipping belts, loose clutches, and reports any other information that the foreman or workman operating the machine should know.









Factors that Determine Necessity for

Replacing Obsolete Equipment

By G. A. VAN BRUNT
Editor, Industrial Engineer

REPLACEMENT of obsolete power drive equipment is one of the important problems with which every industrial operating executive has to contend more or less continuously. When the productive capacity of a plant is being increased, or some of the equipment in use has been destroyed by fire or accident, the problems that are presented are reasonably clear-cut and definite.

These problems resolve themselves largely into a matter of determining what the service requirements are and then selecting the make and type of equipment that will satisfactorily meet these requirements. But what of the equipment that has been in service for some years and is beginning to show signs of the wear and tear that usage inevitably exacts?

The cost of keeping this equipment in service is probably becoming larger each year, as shown by the repair shop records; it needs more frequent inspection and other attention. All of this means that the production delays which can be charged up to it are becoming more frequent, and possibly more costly.

With the proper maintenance attention, including replacement from time to time of such parts as wear out or become damaged beyond repair, it would be possible to keep many items of equipment in service almost indefinitely. The expense and obvious disadvantages of such a course will, however, be apparent at once to every experienced operating executive.

There comes a time in the life of every important piece of equipment when it can no longer be operated profitably in view of the increasing cost of maintenance and repairs, the greater likelihood of breakdown, the lower efficiency, and the lack of desirable operating features possessed by later designs available.

On the other hand, to replace serviceable equipment without adequate justification, is an inexcusable waste of money.

Bearing all of these points in mind, how can the problem of replacing obsolete equipment best be handled? What sort of yardstick, so to speak, can be devised that will enable an operating executive to attack the problem intelligently?

The answers to these questions were sought in the experience of a number of readers of INDUSTRIAL ENGINEER. These men, who are associated with well-known plants in various industries, were asked to tell whether they have a definite schedule for handling replacements, and to enumerate the factors, such as age, trouble from an operating standpoint, excessive repair cost, lower efficiency as compared with new devices, and so on, which they consider to be the most important in determining the advisability or necessity of replacement. They were further asked to discuss the considerations, such as first cost, saving in operating labor, saving in maintenance and repair costs, design and construction (insofar as these affect simplicity and accessibility), and the like, that they regard as important in the selection of new equipment. The answers which these readers have given in the light of their experience, are presented in the following pages.

As a supplement to these accounts manufacturers of some of the more important types of power drive equipment were asked to give their viewpoint on the factors that should be given consideration in determining the advisability of replacement, based on their experience in designing and manufacturing such equipment and watching its performance in the field.

How Replacement of Equipment Is Handled in Seven Industrial Plants

Before major repairs are made to any direct-current motor, E. A. MULVAINE, POWER AND MAINTENANCE ENGINEER, *The Marion Steam Shovel Co., Marion, Ohio, checks the estimated cost of these repairs against the cost of a new alternating-current motor. His policy is to find the most economical way of getting a motor to render a certain service for a given time.*

DUE to the fact that we have very few mechanical drives in our plant, this article will be confined to the replacement of motors.

We do not have any definite schedule arranged for the replacement of a motor or control when the equipment begins to fail. However, when this occurs, we try to locate the cause of the trouble and if it can not be eliminated, we replace the equipment with one suited for the exact conditions. Our principle causes for replacements are overloads, open motors in dirty places, bearing trouble due to bearings not being sealed, and other defects that lead to a breakdown.

All of our d.c. motors operate at 550 volts. When one of these motors fails and requires major repairs, such as rewinding the armature, new field coils, or new commutator, the required repairs are made if the motor is an adjustable-speed motor. Our reason for repairing the adjustable-speed d.c. motor is that we would have to replace this type with an exact duplicate, which would cost considerably more than repairing the old motor.

When a d.c., constant-speed motor fails and requires a major repair it has been our experience that the costs of repairing this motor would be almost as much in some cases as buying a new a.c. motor. When we check up and find the prices about equal or slightly greater than the cost of an a.c. motor, we replace the d.c. motor with a new a.c. induction motor, as we also have available in our plant 440 volts, 3-phase 60-cycle a.c. current.

In case of failure of an a.c. motor, we always determine whether it is cheaper to repair or to buy new equipment. When considering the repair or replacement of a motor the action taken depends on the most economical way of getting a motor to do a certain kind of work for a given time, regardless of whether the motor is repaired or replaced. That is, the cost of repairs are checked against the cost of a new motor. We must also check the life of the repaired motor against the life of the new motor, as well as the additional maintenance cost of the repaired motor against the maintenance cost of a new motor.

In our plant recommendations to replace motors originate in the electrical maintenance department. We keep an accurate record of repairs on our equipment, and the cost of these. We feel this is necessary, and a great aid in he'ping us to determine when any electrical motors or equipment should be replaced, or whether it is being properly taken care of. We believe the following are the most important factors determining the replacement of motors, in the order of their importance: (1) Trouble from an operating standpoint. (2) Excessive maintenance and repair costs. (3) Difficulty in getting repair parts. (4) Low efficiency.

When replacing equipment we do not consider the make of the old apparatus, as we have now standardized on all of our new equipment and any replacements or new items are ordered to the standards, except in the case of some specialties which are made only by some particular company.

In purchasing any equipment the factors considered are listed in the order of their importance. (1) Saving from an operating standpoint. (2) Saving from a maintenance and repair cost standpoint. (3) Design and construction. (4) Cost of equipment.

We have a fairly large plant, operating about a thousand motors ranging in size from ¼-hp. to 750-hp. rating.

First cost is often accorded too much importance in the purchase of new equipment, in the opinion of C. D. CORWIN, WORKS ENGINEER, *L. C. Smith & Corona Typewriters, Inc., Syracuse, N. Y. Before selecting new equipment he compares it carefully with the old apparatus from the standpoint of operating troubles and probable repair costs.*

WE HAVE no definite schedule for replacing obsolete electrical or mechanical power drive equipment in our plant.

Recommendations for such replacement may originate with the millwright foreman or electrical foreman, or with the works engineer. They may also be suggested by the foremen of different departments. In any case, the matter would be investigated at once and the final recommendation would be made by the works engineer. An accurate record of the cost of replacement of all important pieces of equipment is maintained.

In determining replacement, the efficiency of the proposed apparatus as compared with the obsolete apparatus is always investigated for troubles from an operating standpoint as well as repair costs. The problem of the age of the equipment has very little to do with it, if the other items are satisfactory.

In replacing equipment, if the device has been entirely satisfactory and has given as long life as could reasonably be expected, new equipment of the same make would undoubtedly be purchased, but not until similar equipment of different makes had been thoroughly investigated.

When selecting new equipment the writer considers the following factors, listed in the order of their importance: (1) Saving in operating labor. (2) Saving in maintenance and repair costs.

This last item really depends upon the design and construction of the apparatus.

The first cost of the machine is, of course, taken into consideration in arriving at a decision, but the writer believes that too often "First Cost" is permitted to have too much weight.

Equipment should not be replaced at random, merely because it is less efficient than newer devices, in the opinion of H. E. STAFFORD, ELECTRICAL ENGINEER, *Provincial Paper Mills, Ltd., Port Arthur, Ont., Can. He advocates a careful study of conditions, which may show how the efficiency of a drive may be increased by minor alterations.*

THE company with which I am connected has no definite schedule for replacements of either electrical or mechanical drive equipment, such replacements being made when the cost of repairs offset the operating value of the equipment. As all of our equipment is motor driven, it falls to the lot of the electrical department to determine the operating efficiency of the various units.

This is determined by means of load tests, one of which I described fully in an article in the July, 1925, issue of INDUSTRIAL ENGINEER. A load test of the entire plant is made yearly and when any discrepancy in the load is noticed, tests are immediately made to determine definitely the source of the trouble.

If trouble is experienced on a belt drive, for instance, or if belt repair costs are excessive, or power consumption increased due to tightening of the belt in order to reduce slippage, the matter is immediately taken up with the superintendent of that department regarding the advisability of changing to chain or some other drive.

Where improvements can be made in the control of a given motor, as changing from a compensator to a remote-controlled magnetic breaker or starter, the recommendations usually originate in the electrical department. A case in point would be the control of an elevator leg or conveyor where the operator is situated at some distance from the starter.

Recommendations for replacements of electrical equipment, as stated above, originate with the electrical department, while those of a mechanical nature may originate with any of the superintendents, or with the master mechanic.

With both types of equipment an accurate record is kept of not only the major repairs, but minor repairs as well.

The most important factor in determining replacements, from my point of view, is a combination of trouble from operating standpoint and excessive repair cost. If a machine or drive is giving excessive trouble, the repair costs will be excessive in any event. In addition to repair costs, there is also loss of production.

Relegating equipment to the junkpile on account of lowered efficiency and replacing it with more modern equipment should not be done at random. In the first place, a little study of the drive and equipment will often result in increased efficiency by making a few minor changes or sometimes by shifting or substituting one piece of equipment for another.

Whether new equipment for replacement should be of the same make as the old, depends on circumstances. In the first place, greater economy lies in standardization. For instance, suppose an industrial plant has a dozen machines which are identical. It would be poor policy to replace one of these by one of a different make, as double the repair parts would be necessary. On the other hand, if we find a certain machine, drive or control is giving continuous trouble, with the consequent loss in production, it will certainly pay to scrap the unit and install one which can be depended upon.

Saving in operating labor should be the most important factor to consider in purchasing new equipment. The reason for this is that if the useful life of a piece of equipment is ten years and it can be operated by even one operator less, the saving thus made will pay for a large amount of repairs.

Saving in maintenance and repair costs is the second factor in importance, for if equipment requires little or no repairs, it must be well designed and does not necessarily require a great degree of accessibility.

Design and construction are about on a par with first cost; a simple design will require less repair parts than a complicated design, and a good piece of equipment is cheap at any price.

In the selection of new equipment to replace obsolete devices, K. D. HAMILTON, MECHANICAL DEPARTMENT, *Geo. E. Keith Co., Brockton, Mass., considers saving in operating labor to be more important than first cost. Design and construction, in so far as these affect maintenance cost, are next in importance, in his estimation.*

THERE is no definite schedule or basis upon which we replace electrical or mechanical equipment.

Recommendations for replacement originate in the Mechanical Department.

We keep an approximate repair cost on all important machines.

Age is not a deciding factor in the replacing of machinery. If the machinery is in good condition it is kept operating regardless of its age. Trouble from an operating standpoint is a deciding factor in the replacement of equipment. Excessive repair costs are also a deciding factor. Lower efficiency as compared with newer devices and improvements is likewise an important item in determining whether a machine shall be replaced or not.

When replacing equipment we do not always go to the same make, provided new devices are on the market which will improve the operation of the machinery.

In the replacement of machinery we consider the following factors of importance: (1) Saving in operating labor. (2) First cost. (3) Design, as it affects maintenance cost. (4) Construction and accessibility.

Operating troubles, leading to production losses and high maintenance costs, together with improvements embodied in the design of new equipment, are the most important features in determining replacement, according to J. ELMER HOUSLEY, ELECTRICAL ENGINEER, *Aluminum Company of America, Alcoa, Tenn.*

MANY industries having a large power consumption have found it desirable to base their depreciation schedules on the basis sanctioned by the various public utility commissions. This, however, is applicable chiefly to the problems of accounting. It more frequently happens that electrical and mechanical power drive equipment is replaced before depreciation has wiped out the original cost of the equipment. Whenever such equipment is replaced the procedure is co-ordinated between the operating, engineering, executive, and accounting divisions of the company. Such replacements, of course, may well originate anywhere within that circle.

We may enumerate the most important factors in determining replacement, in the order of their relative importance, as follows: (1) Production losses from breakdowns. (2) Advances in engineering design. (3) Excessive maintainence charges. (4) Age of equipment, which is a minor factor. The first two causes are determined from operating and production reports. The third is determined by accurate cost records which are indispensable in the operation of any manufacturing plant. The fourth cause does not need to enter the discussion except as it may appear in one of the first three causes affecting replacement. It may be interesting to follow through this reasoning as applied to one type of equipment, such as the induction motors produced in the year 1910.

About 20 of these motors remained in service up to a short time ago, having been in use for 15 yr. Reports showed that a large percentage of production delays and losses occurred on drives equipped with these motors. Reports of the electrical department showed that the maintenance charges against these motors were more than double those of motors of more modern design. In comparing the design of the old and the new motors it was found that the former had a very small shaft, and that the bearing bushings were short and extremely difficult to line up in the motor endbell. Also, the construction of the rotor bars and end rings was such that the bars would come loose, creating a high-resistance joint which caused a drop in speed of the motor at first, and, later, complete inability to carry any load. In consequence, the entire group of motors of this design was withdrawn from service and replaced with motors of advanced design.

In this particular case all four factors were involved in the replacement of this equipment. The new motors were selected from various manufacturers, as we wished to obtain motors which had the desired mechanical and electrical characteristics in the particular sizes required for the drive to which they were applied.

In generalizing we may say that new electrical or mechanical equipment for replacement should be considered, (1) from the standpoint of its adaptability to operating conditions (nature of plant and materials handled). (2) Low inherent maintenance cost (other than that caused by improper application). (3) Convenience and safety to operators (involving also low operating costs).

Before the purchase of new equipment is recommended, W. E. MULROONEY, CHIEF ELECTRICIAN, *The Carbondale Machine Co., Carbondale, Pa., balances the cost of repairing and maintaining the old equipment against the cost of new apparatus. In selecting new equipment, he chooses only that of the latest and most efficient type.*

NO DEFINITE time schedule is used for replacement of equipment in our plant. Some part of the apparatus, perhaps a motor or starter, may become obsolete due to later and better designs, but if the piece in question still gives adequate service without a great deal of attention we continue its use.

Recommendations covering replacement of apparatus are made by the chief electrician. An accurate record of all repair replacement and maintenance costs are kept by a department in the general office. The chief electrician has access to these costs at all times. Before recommending new equipment several factors are considered and analyzed and the records studied to arrive at a comparison of the over-all cost of maintaining and repairing the old equipment against the cost of new equipment.

If it is decided to purchase new equipment, only the latest and most efficient type is recommended. The age of present equipment is not considered, so long as the piece gives good service. Many of our d.c. motors are over 20 yr. old, but are still giving trouble-free service.

When replacing equipment our policy is to standardize as far as possible, always considering the service

required as well as first cost. This applies particularly to motors. Controls are selected to suit different conditions and may or may not be of the same manufacture as the motors.

When purchasing new equipment the most important factor to be considered is hardly definable. Saving in maintenance cost is, of course, desirable. However, first cost must be considered as well as operating cost. It would seem that if the design and construction is such as to be fairly simple and accessible the maintenance cost will naturally be less. In our case, the purchase of new equipment is considered from all angles, and no one factor predominates. However, from the viewpoint of the Electrical Department, obviously simple design and construction, and accessibility for repairs are very desirable.

An accurate record of the cost of repairs to all important electrical and mechanical power drive equipment is the real basis used by J. S. MURRAY, CHIEF ELECTRICIAN, *Follansbee Brothers Co., Toronto, Ohio, in determining obsolescence of present equipment. When repair costs on a piece of equipment become excessive, it is either scrapped or altered so that it will meet operating requirements with less maintenance expense.*

IN OUR plant a general schedule is followed from which we get some help in determining the proper time to discard obsolete equipment. Recommendations to replace obsolete equipment originate in our department and are approved by the general manager before the work is carried out.

We keep a record of the cost of repairs to important electrical and mechanical power drive equipment, which is the real basis of our decisions regarding obsolescence of equipment. If a piece of equipment is expensive to maintain, we either scrap it or modify it so that it will meet our particular conditions at a reasonable maintenance figure.

In determining obsolescence we consider the following factors most important, in the order given: (1) Excessive repair costs, because these usually involve loss of production, also. (2) Trouble in operating the equipment. (3) Lower efficiency of old equipment, other things being equal, particularly because of the savings that are sometimes made in an improved product and decreased manpower.

In replacing equipment we are governed somewhat by standardization. This, together with the consideration mentioned above, determine to a large extent our selection of new equipment.

We consider saving in maintenance and repair costs and simplicity of design and operation most important. We do not give the question of first cost a large amount of consideration, as our main object is quality both as to what we purchase and what we manufacture to sell.

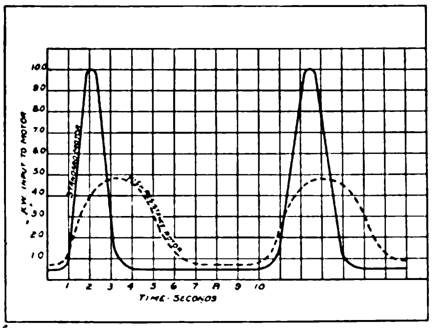
The Manufacturer's Viewpoint on Replacement of Equipment

Motors

In the opinion of A. F. DAVIS, VICE-PRESIDENT, *The Lincoln Electric Company, Cleveland, Ohio, electric motors become obsolete in several respects, among which are changed power requirements of driven machines and advances in motor design; consequently, replacement is frequently justified.*

WHEN electric motors were first installed to drive power machinery, it was believed that the motor would last forever. This belief was substantially correct. By far the greater part of all of the motors which have been built are still in service. The reason for this situation lies in the inherent nature of motor construction, which permits repair or replacement of windings or mechanical parts.

Some motors have become obsolete because it costs more in power to operate them than it would to send them to the scrap pile and install new equipment. It is the general belief that where induction motors can be installed to replace direct-current motors, the reduction in maintenance and increased reliability of operation will justify the capital outlay required. This, of course, is an example of replacement of obsolete equipment. It would be difficult to justify the replacement of constant-speed, direct-current motors in general on the grounds of lower maintenance cost alone, although the maintenance cost of induction motors is certainly less than in the case of direct-current motors. But the reduction of motor failures by the use of induction motors, where possible, results in greater continuity of operation of the motor-driven machinery. Under modern conditions, shutting down essential equipment results in such large losses that very large expenditures are justified for the prevention of such shutdowns.



A properly designed motor used with a flywheel will allow the latter to carry peak loads.

The full line shows the current peaks drawn by standard, squirrel-cage motor with flywheel, when a momentary peak load comes on. The dotted line shows the behavior of a motor with a high-resistance rotor under the same conditions.

Replacement of induction motors on the ground that they are obsolete is justifiable in some cases. The rotor design of early induction motors was poor, with the result that open-circuited rotors were frequently found. It pays to replace such motors with those that have modern welded, cast or solid rotor construction.

By far the greatest number of induction motors which may justifiably be replaced are those which have been misapplied, through poor engineering. Such motors should be put into the second-hand dealer's stock where they can be sent out to drive loads to which they are properly applicable. The most flagrant example of poor engineering in motor application is overmotoring. There are thousands of motors in operation today on which the maximum load never exceeds 30 per cent of the nameplate rating of the motor. Replacement of such motors with smaller ones is economically justifiable, due to the increase in both power factor and efficiency that will result.

The effects of poor engineering in early motor application work are apparent in other ways besides overmotoring. An example of this is the use of a standard squirrel-cage motor for driving a punchpress or other machine that takes the energy for the power stroke from a flywheel, where it has been stored by the motor. The standard motor, owing to its characteristics, will bring the flywheel back to full speed after the power stroke in a fraction of the time allowed for the purpose, with a power draft from the lines of several times the amount actually required.

In this case the proper type motor, which is a squirrel-cage design with a high-resistance rotor, will bring the flywheel back to speed in the full time allotted to the operation, with a correspondingly lower draft on the power lines. This is shown in an accompanying illustration. Replacement of a standard motor by a high-resistance, squirrel-cage motor designed for this purpose, is justifiable because it will result in a substantial reduction in the power bill and an increase in the power factor.

Developments of the past ten years have shown conclusively that slipring motors have been applied in many cases to loads which could have been handled much more economically by the squirrel-cage type of motor which costs about half as much, has a better power factor and, on the average, better efficiency. On these grounds, as well as to secure a reduction in maintenance costs, a good many slipring motors have been justifiably replaced by squirrel-cage motors. Examples of this kind are frequently found in hoists, car pullers, elevators and sim-

ilar equipment where the starting load is very large as compared with the running load.

An interesting question has been raised as to how long it will be before the motors we are installing today will be obsolete. It seems reasonable to suppose that a great many of the structural defects of motors have been corrected in the past 20 years. Substitution of hot-rolled steel for the cast-iron motor frame has resulted in a practically indestructible piece of equipment. We know that we are at the limit of efficiency of the motor as an electrical machine. It seems reasonable to suppose, therefore, that it will take longer for present-day motors to become obsolete than it did for the motors built 10 or 15 years ago. More attention is being paid to the application of motors to the job, so that obsolescence from that source is certainly being materially reduced. Yet it would be the rankest folly to presume that the end of motor engineering is at hand. The induction motor principle has been applied only to rotating devices that we call induction motors; it might be applied to power devices that would bear little resemblance to the present induction motor and yet would effectively serve the purpose of converting electrical energy into mechanical energy.

Motors of modern design possess so many desirable operating characteristics that A. G. AHRENS, MOTOR APPARATUS DEPARTMENT, *Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., considers the replacement of old motors to be justified in many instances.*

NUMEROUS and varied are the reasons that might be set forth for the replacement of motors in industry. And yet, in the final analysis, actual practice in industry demands that any such change in equipment must satisfactorily answer the question, "Does it pay?"

Modern motor equipments offer valuable operating advantages, such as improved speed acceleration, accurate speed regulation, more effective protection against line disturbances, and others. These bring about impressive benefits in the way of increased production, continuous production, lower costs, and better working conditions, which justify changes in motor drives where obsolete equipment is in use. Many examples of such replacements which have worked to the decided advantage of both the industry and the workers, are to be found in the steel, paper, and mining industries.

A very potent fact, and one that should always be in the minds of those contemplating changes in drives, is the question of maintaining a high wage scale, and at the same time reducing manufacturing costs. To do this requires that more efficient processes be developed, and that serious consideration be given to obtaining the most effective and efficient motor drives.

Wear and tear and accidents, are, of course, the most familiar causes for replacement. All of us realize that even the best machinery wears out, and that accidents cause damage. These facts very obviously help to decide the question, "Does it pay," when replacement of motors is being considered.

An important point to remember in ordering motors for replacement, is to make sure that the motors and controllers selected are not only large enough to take care of the existing requirements, but also to take care of the changes that may be made in the future, in order to obtain increased production.

The systemizing and modernizing of shops is important. Given the most effective kind of equipment, if performance records are maintained it is a simple problem to discover where repeated breakdowns are occurring, and prepare for them by keeping on hand a sufficient stock of wearing parts, and those parts most liable to injury by accident. This will prevent many production delays, at a cost that is a comparatively small part of the total investment.

Bearings have been improved so much that N. S. YOST, ELECTRICAL ENGINEER, *Howell Electric Motors Co., Howell, Mich., considers that replacement of sleeve-bearing motors may be justified by the reduction in maintenance cost.*

SO FAR as efficiency, power factor, and the like, are concerned, there should be no reason for scrapping old motors. The copper losses do not increase at all with age, and the iron losses increase only slightly. Practically, however, the deterioration of insulation is so fast in most cases that rewinding is necessary long before the remaining parts of the motor are obsolete. Repeated rewinding tends to destroy the core insulation and to spoil the tooth tips, especially in semi-closed slots, which has the effect of lowering both the efficiency and the power factor.

The greatest improvements in motors during recent years have been made in the bearings, so that scrapping of sleeve-bushed motors may be warranted on account of lower maintenance charges.

Control Equipment

In time the cost of maintenance and repair parts for old control equipment becomes so high, according to W. J. STOCK, INDUSTRIAL CONTROL DEPARTMENT, *General Electric Company, Schenectady, N. Y., that money can be saved by replacing it. In addition, modern control devices offer many opportunities for cutting operating costs.*

THE question of replacing obsolete control devices is one that presents itself to the plant executive from time to time, and may be settled definitely by considering that vital factor in which every executive is interested—cost, both of maintenance and of operation. This cost may show up in a variety of ways and places, and a rather careful consideration of the various conditions is necessary in order to analyze the situation and arrive at a real solution of the problems presented.

The majority of control manufacturers are able to supply repair parts over a long period of years after a device has become obsolete. However, the cost of these parts gradually increases until in many cases the cost of renewal parts is almost equal to the cost of a new control of up-to-date design. In addition to the cost of parts, the cost of installation of these parts must also be considered; this will depend upon the condition of the control equipment. Just how high this combined cost must be to justify scrapping the old equipment, depends upon the individual case, although a definite rule may be laid down for guidance.

In applying this rule, however, the fact should not be lost sight of that all control equipments, whether old or new, are subject to wear from usage and a certain repair charge is justified. The amount of this justified charge depends upon the severity of the operating conditions. Obviously, the repair charge on a control equipment that operates 20 times a minute continuously will be higher than that on equipment that operates only once a day.

With the above in mind, it may be said that where the difference between the cost of upkeep on obsolete equipment and the cost of upkeep on new equipment on the same application, over a period of a year, is greater than the interest and depreciation charges on the cost of the new equipment, scrapping of the old control is justified. Due to the increasing cost of repair parts for the obsolete device as it becomes older, it is obvious that this difference will increase from year to year, until eventually the continued use of the old control will represent an actual loss to the user. This presupposes that the operation of the obsolete equipment when repaired is as satisfactory and the resultant production as high as with the new control, although this is rarely the case.

Much consideration should be given to the fact that modern control schemes and devices make possible a much lower operating cost, because of the economies which are effected. For example, the thermal overload relay allows an operator to obtain the maximum amount of work from a motor without any danger of burning it out. Delays due to burned-out motors, and the resultant charge for rewinding, should be eliminated as much as possible, and the use of a correctly adjusted thermal overload relay is one means of doing this.

In many installations the use of push-button control of up-to-date design has eliminated a certain amount of manual labor previously required when an older type of control equipment was used. Until the advent of the full-magnetic synchronous motor starter, it was necessary that an engineer or factory executive be present to start up a synchronous motor. Now, an ordinary laborer can accomplish

this by merely pressing a starting button. There are numberless applications where, by means of magnetic control, including timing relays and limit switches, it is possible for one operator to look after a large number of machines. It is only necessary for him to start the machine at the proper time and the cycle of operation will be automatically carried along by the control. In many cases when space is at a premium, the magnetic control panel may be installed near the ceiling or in an adjoining room where space is available, with only the push button located near the machine and the operator.

All of these factors result in lower operating expense or a high production rate for the same number of operators; in either case a reduction in cost results. Therefore, careful consideration may well be given to the possibility of reducing the cost of operation by replacing old control devices with those of up-to-date design.

Control equipment should be considered as part of the motor, H. L. VAN VALKENBURG, CHIEF ENGINEER, *Industrial Controller Co., Milwaukee, Wis., points out, as it supplies characteristics that are not embodied in the motor design. It is justifiable to replace equipment that does not meet operating requirements.*

THE problem of when to replace controller equipment is more or less governed by the conditions existing in an industrial plant.

The proper understanding of an electric controller requires that it be considered as a part of the motor. The controller should be designed to take care of the functions not incorporated in the motor design, in order to enable the latter to operate under the specified conditions of load.

Every motor has certain inherent characteristics which enable it to adapt itself to some of the conditions encountered in practice. In many cases, however, the motor would be very expensive and also inefficient if it were given the necessary characteristics to prevent it or the driven machine from being injured, during the cycle of operation.

The most prevalent justification for replacing control equipment is that the present installation does not satisfactorily meet the requirements. The old style of controller providing overload protection by means of fuses is being discarded in modern plants for devices giving overload protection by magnetic or thermal relays.

A recent incident that fully justified the replacement of control equipment may prove interesting, as it covers a condition that is encountered daily. A manufacturer of hosiery found it necessary to increase his production without providing additional floor space. This required the rearrangement of all machinery and the discarding of all manually operated controllers, which were replaced with automatic devices that could be located in such a position that they would not occupy any floor space and still be accessible. The adoption of automatic controllers solved the problem.

The life of control equipment should be measured in terms of the value, rather than years, of its service, says G. O. WILMS, CHIEF ENGINEER, *Allen-Bradley Co., Milwaukee, Wis. He considers that it is economy to replace any equipment that does not meet modern operating requirements and conditions.*

IT IS rather difficult to make a definite statement as to the life of motor control equipment, inasmuch as this depends largely on the service conditions. A control that is used only to start a motor several times a day will long outlast equipment that has a severe duty cycle to perform. If wear only were to be considered, some control equipment could, with little care, be made to last almost indefinitely, whereas other similar equipment that is in hard service and is given but little attention will have a limited life.

It seems, therefore, that the length of life of control equipment should be measured on the basis of the service it renders. In this respect control equipment is no different from any other device. A textile machine whose output does not come up to modern standards in both quantity and quality has outlived its usefulness, even though it may still be in good mechanical condition. The same thing holds true for machine tools, and other equipment. However, a machine may also be considered to have outlived its usefulness if the cost of keeping it in operation becomes excessive.

Years ago a simple, hand-operated control would fulfill all requirements; delays in starting, or the necessity of having a skilled man operate the control properly, were not important. Shutdowns due to repairs, or time unnecessarily wasted in machine operation, increase the unit cost of the product and steps should be taken to remedy such conditions, if the producer wants to get his share of business at a price that will insure profits.

Open-type, hand-operated equipment is obsolete and should be replaced, as it is not only dangerous to operate, but is the cause of delays in machine operation, unless the operator is thoroughly familiar with the equipment. A man who is not familiar with its operation is likely to cause an accident or delay, due to his carelessness or his fear of the equipment. A push button, removed from the control and from the machine, can be operated by anyone, no matter how unskilled or careless he may be, and the factor of fear does not enter at all.

Control equipment that is not provided with no-voltage protection is obsolete and may be the cause of serious accidents both to the machine and the operator, due to unexpected starting of the machine after a voltage failure. Even a minor accident may cost many times the price of a modern control equipment.

Motor starting equipment that employs knife switches, particularly where frequent operation is necessary, should be replaced, as such equipment is likely to be dangerous to the operator. Where such equipment is used on machines that are not in continuous operation, operators are inclined to let the motors run idle rather than operate the switch. The cost of the power unnecessarily used would soon pay for push-button-operated starting equipment.

Starting equipment, either manual or automatic, that puts undue strain on the driven machine or causes belt slippage should be replaced. The cost of a broken gear or burned belt may amount to a good deal more than the cost of modern starting equipment that will insure gradual starting of the motor.

Control equipment, either old or new, that is subject to breakdowns, due to age, misapplication, or more severe service than it was designed for, should be replaced.

No doubt our present type of control will be obsolete ten years from now, but we should not regret this, as it will be brought about by such advances in design that the advantages offered will more than pay for new control equipment, as is now the case.

When the cost of maintaining old control equipment exceeds the interest charges and the probable cost of maintaining new equipment, R. G. WIDDOWS, SALES MANAGER, *The Electric Controller & Mfg. Co., Cleveland, Ohio, considers that the old apparatus may justifiably be replaced.*

THERE can be no set rule to determine when control equipment should be replaced. In general, when the cost of maintenance of the old equipment exceeds the interest charges plus the probable maintenance costs on new equipment, the old equipment may be discarded, provided there is money available for new control apparatus. In many plants, however, it is not an easy matter for the operating department to secure appropriations for new equipment, in which case they will struggle along with old apparatus, which may be very expensive to maintain.

By replacing obsolete equipment with new controllers, important economies may in many cases be secured, due to increased production, reduction in delays, saving in power due to shutting down motors and machinery during idle periods if the process is an intermittent one, reduction in fuse expense, and reduced maintenance charges on the motors. These economies can be secured by replacing obsolete, hand-operated starters and controllers with the more modern push-button-operated equipment. Many plants are finding it profitable to install push-button control as rapidly as their hand-operated equipment reaches the point where a major overhauling is needed.

Considerations of safety may in many cases justify the change-over.

Older styles of starting equipment frequently do not incorporate overload and low-voltage protection, and in the case of a.c. starters, phase-failure protection is often lacking. All these protective features can be secured with the modern push-button-operated equipment.

In industries where a fire hazard exists, or where the atmosphere is corrosive, it will oftentimes pay to replace old-style, air-break control equipment with modern, oil-immersed automatic compensators and across-the-line starters, as this equipment practically eliminates the fire hazard on account of its flameproof features, and will withstand corrosive atmospheres without deteriorating.

Rubber Belts

Usually it does not pay to patch a rubber belt more than once, in the opinion of E. J. BLACK, THE DIAMOND RUBBER CO., INC., *Akron, Ohio, in view of the comparatively low cost of such belts.*

INASMUCH as rubber belts are moderate in cost, as compared with some other types, there is not the same degree of economy in patching and repairing them. A good, practical rule is to make but one patch on a belt. That is, if it has previously been found necessary to insert a piece at the point where the fastening occurs, when the ends fail the second time, it is usually better to replace the belt, rather than to spend additional time in making repairs, with the attendant loss of time and production. Sometimes a piece of such a belt can be salvaged for use as a fill-in on some other belt, but often it is more economical to discard it entirely.

There is nothing extravagant in such a course, for when they are properly applied on drives operating at moderate speed, and are protected from lubricating oil, rubber belts will often give from 6 to 10 years, and sometimes even 18 or 20 years of service. In order to secure such service as this, it is necessary to make an individual study of each drive, so that the belting may be of the right type and ply.

Careful attention should also be given at regular intervals to the pulleys and shafting, as a slight misalignment causes the belt to stretch on one side, and materially shortens its life.

Whenever there are frequent replacements of belting on a particular drive, the plant engineer should give that drive careful thought. Perhaps the speed is too low. This puts a great strain on any belt. Or the pulleys may be too small, or too narrow. Either fault will seriously affect the service of any belt. Again the belt may be too heavy for the work. This is the real difficulty in an astonishing number of cases, especially with short belts.

Belt dressing should be used very sparingly, and never where there is much dust. In dusty places the life of the belt may be considerably increased by occasionally cleaning with linseed oil, after which the belt should be allowed to dry over night before using. This treatment obviates the necessity of keeping the belt excessively tight in order to carry its load, and enables it to give better and longer service.

When the operator feels that a dressing of some sort is necessary, castor oil may be used. There are also one or two commercial belt dressings that may be used sparingly, but where the installation is a normal one, and the belt properly applied, there are few cases where a dressing is really needed.

If every factory using rubber belts would make it a rule that, wherever possible, all open-end belts are to be replaced with endless belts as they wear out, a very great saving would result. In the great majority of cases failure occurs at the point where the two ends are joined. The use of endless belts eliminates this trouble, increases the efficiency of the belt, and saves much of the cost of upkeep and repair. In fact, the use of endless belts would produce so great a saving that in many cases it would be worth while to make any necessary changes in equipment, so that endless belts might be used.

Leather Belts

When properly applied and cared for, CLAUDE O. STREETER, MECHANICAL ENGINEER, *Graton & Knight Co., Worcester, Mass., points out, a leather belt will last almost indefinitely. The question of replacement must be decided for each case individually, rather than on the basis of a rule or formula.*

THERE are so many factors influencing the life of leather belts that it is almost impossible to draw any convincing conclusions regarding the service that a belt will give before it has to be replaced.

In one industry conditions may be so severe that five or six years of life are all that can be expected, whereas in another industry a leather belt will last beyond the memory of several generations.

An appraisal will take into consideration a 40 per cent annual depreciation on leather belting, so that in about 15 years the leather belt equipment, insofar as bookkeeping is concerned, is worth approximately nothing.

On the other hand, there is the Centennial belt which has been in operation since 1877 and is still giving satisfactory service. This is only one of myriads of leather belts that are rendering similar service.

Practically, we find that a leather belt that is properly adapted to a drive and given a reasonable amount of attention never actually wears out in the sense that it is absolutely unusable.

True, a wide belt may pass its days of usefulness on its original drive, due to increase of power requirements, accidents, drive rearrangement, and so on, but this is only one stage in its existence. It is then available to be made into narrower belts, and this reworking operation may be carried on, it is safe to say, indefinitely, as no one actually knows the limit.

Determining when a leather belt has passed its days of usefulness in any of the several stages of its life, is simply a matter of applying common sense.

For instance, let us assume that some 20 years ago a leather belt was installed on the main drive of a plant and at the time of installation the belt was properly proportioned to the drive.

Since then the business of this plant has grown, new equipment has been added to take care of this increase, and old equipment has been speeded up to increase production, until one day the old belt begins to complain and it is looked over. We find that it has narrowed down in width and has started to break through in the center.

This condition is alarming and consequently the load is checked up. We find that the belt is carrying 50 to 100 per cent more than its rated capacity, and it is apparent that although this load increase has been gradual, the belt has been carrying the largest part of it for several years. Hence the present condition of the belt is positively dangerous.

Consideration of the overload to which this belt has been subjected will impress anyone with the fact that the leather has been badly strained, and when the belt is more closely examined we find, in addition to the narrowing down and breaks first noted, that the surface is literally filled with cracks of varying size and depth, clearly denoting the strain to which it has been subjected. An examination of the inside ply shows that in many spots the leather is actually charred, due to frictional heat generated by the belt slipping on the pulleys.

It is apparent there is considerably more service in this belt, but when we consider the fact that it has narrowed down from its original width—and even if it had not, it would not be wide enough to handle the increased power requirement—we are forced to conclude that greater width is imperative.

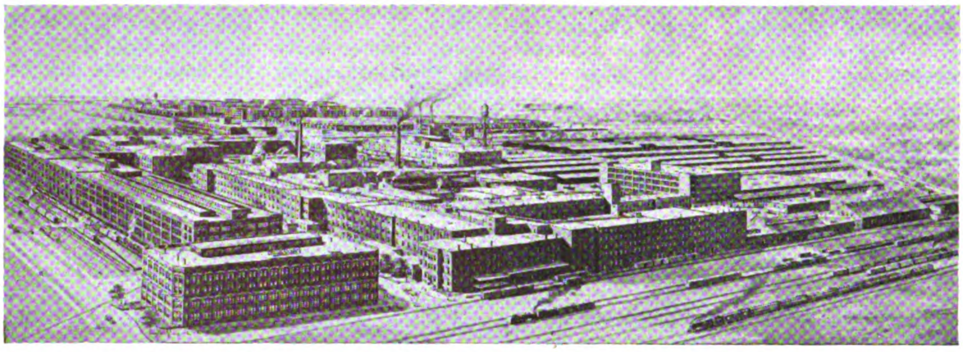
We know that the belt can be worked over and rebuilt to this greater width, but in order to do this the belt must be taken apart, the old glue removed from its several pieces, and the burned and cracked portions cut out. This means a reduction in the thickness of the belt, due to scraping off the old cement, and a shortening of its length from cutting out the damaged stock.

Obviously, new leather must be used to increase the width and maintain the length desired. Part of the resultant belt will then be old, badly-strained leather and the remainder new, live leather. Although the initial investment might be considerably reduced by this practice, the fact, nevertheless remains that we would have a belt of questionable merit and very uncertain characteristics. In other words, it would seem to be more economical to concede that this partcular belt has passed its usefulness in this stage of its existence, and rework it into narrower widths for use in drives where the service is less severe.

ORGANIZED PROCEDURE *in the South Bend Plants of The Studebaker Corporation for the*

Maintenance of Mechanical Equipment and Buildings

FIRST ARTICLE



By IRA De MOSS

General Foreman of Maintenance, Body Division, The Studebaker Corporation, South Bend, Ind.

THE primary object of all industrial plants is to manufacture a product at as low a cost as possible, consistent with the accuracy and quality demanded. The general trend in the automotive industry has been toward increased quality and value in the product at no increase and often at a decrease in price. Much of this has been due to the perfection of machinery and to production in large quantities. Another factor that is no doubt partly responsible is the resultant effect of an increased recognition of the value of adequate maintenance and upkeep to plant, machinery, and equipment.

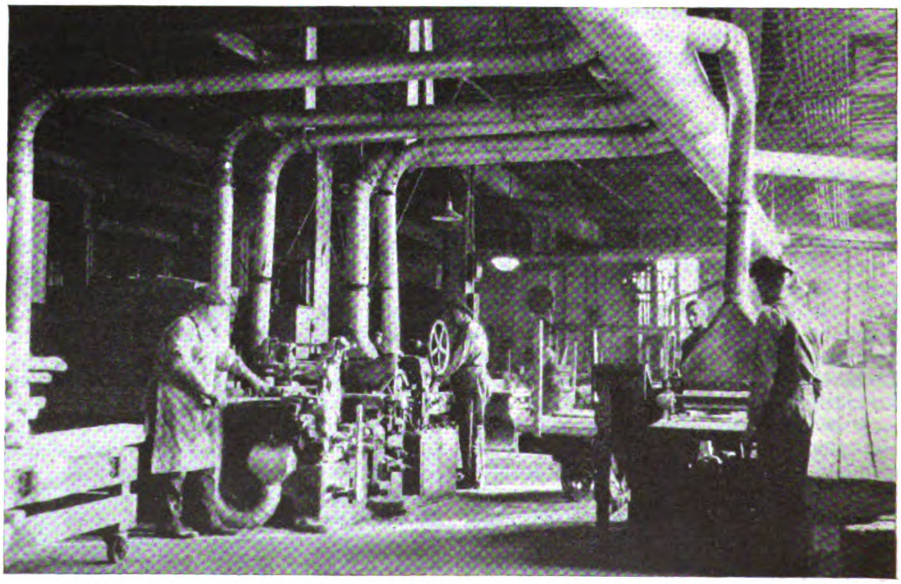
Comparatively few persons outside of the particular industry, however, realize the amount or importance of the auxiliary work necessary to maintain the plant and equipment so that there will be a minimum of necessary interruption, such as periodic overhauling or changing of tools and similar activities which can be planned for, and as few unnecessary or unanticipated interruptions, such as breakdowns, as possible.

Before going further into the description of methods used for taking care of this auxiliary work at The Studebaker Corporation, it may be well to explain first the extent and arrangement of the Studebaker plants at South Bend, Ind. The plants cover a total of 191 acres, not including the proving ground, and comprise a number of buildings with approximately 6,050,108 sq.ft. of floor space.

The Body Division includes a number of large, modern buildings. This plant makes stampings and windshields, and includes all the woodworking and metal-working shops for manufacturing all bodies used on Studebaker cars both in South Bend and in Detroit, and also some of the maintenance repair shops, as will be explained later.

The Chassis Division includes the forge shop, stamping plant, iron foundry, machine shop, and buildings for stores and assembly, final car assembly, car storage, shipping, and power house. The wide variety of operations and types of equipment in the two divisions indicates in a measure the multitude of different problems to be met in the repair and maintenance work.

The routine for handling electrical maintenance and repair work was described in a previous article en-



Two of the machines in the woodworking department of the Maintenance Division.

This woodworking plant is concerned only with the maintenance of buildings and the production of miscellaneous woodworking supplies and devices required in connection with the operation of the plant. Some of the jobs require making only one unit, whereas in other cases hundreds and even thousands are necessary. For example, the 3,000 body trucks used in the building and painting of bodies were all built and are repaired here.

titled "Handling Maintenance and Repairs on 4,000 Motors," which appeared in the February, 1926, issue of INDUSTRIAL ENGINEER; hence this part of the work will not be discussed further here.

Maintenance in the Body Division of The Studebaker Corporation is divided into five departments: machine repairs, millwrighting, woodworking division, body, jig and fixture making and maintenance, and structural and sheet metal. Two of these, the woodworking division and the sheet-metal department, do the necessary work in these lines for both Body and Chassis Divisions; the other departments serve the Body Division only on special occasions. The Chassis Division has a separate machine repair shop and also its own millwrighting, diemaking and maintenance departments.

Because of the large number and special nature of the assembling and cutting dies on body parts, it was considered advisable to have them made and maintained near where they are used, as this would reduce materially the delay and the amount of transportation of these parts. Also, the responsibility would be definitely placed upon the superintendent of the division using them, which is an important advantage when production is so closely tied up with the design, life, and maintenance of these fixtures. The same holds true of machine repairs. The work of these sub-departments will be taken up here in detail.

Machine Repair Shop.—As previously stated, this shop takes care of the Body Division only. The majority of these machines in the Body Division are stamping, forming, and small forging presses, woodworking machinery, and all other equipment incident to body making.

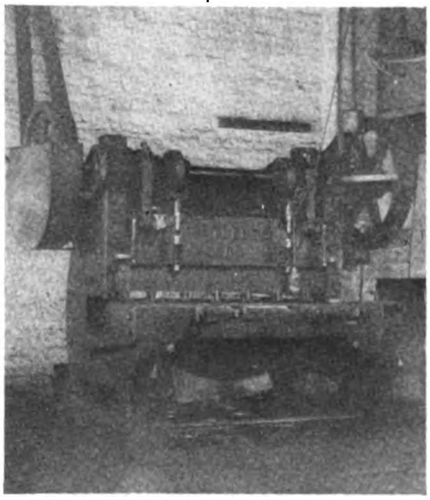


Plate or square shear in the structural division.

This machine will shear ¼-in. plates, 48 in. wide. None of the machines illustrated in this article is used in automobile production.

The machine repair department employs about 46 men under a foreman. Of these, twelve are first-class machinists capable of making a complete new part when desired and of operating any machine in the repair shop. However, most of the men specialize on one or two machines all of the time and the necessary work is passed from one machine tool to the next, as this plan tends to obtain greater output and also does not require as many machine tools. The machines include millers, shapers, planers, lathes, drill presses, and the standard machine tools necessary in a repair shop.

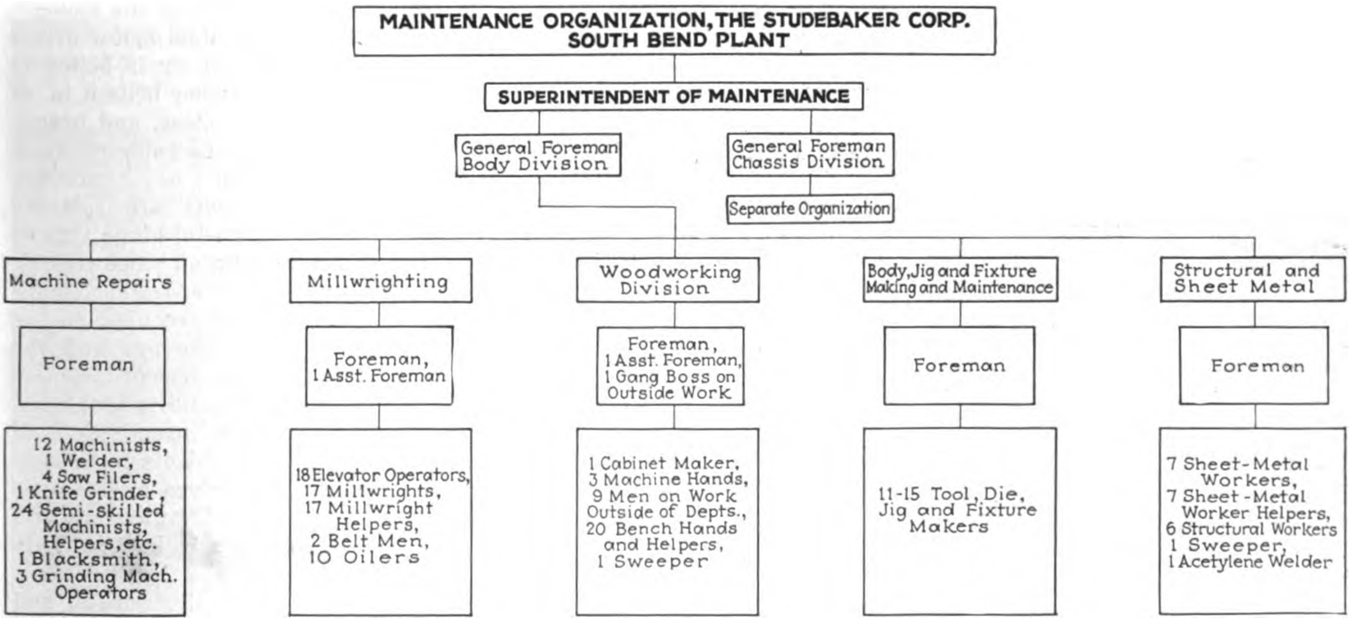
Much of the machine repairs and reconstruction consists of substituting steel for cast-iron parts. Many of these parts are made by building up and forming new parts from flat steel and shapes by means of acetylene welding and cutting torches and then machining them as necessary. One welder is kept busy on machine repairs, although he is sometimes loaned to one of the other maintenance departments. Since all of this work is under the direction of a general foreman it is very easy to shift men from one crew to another.

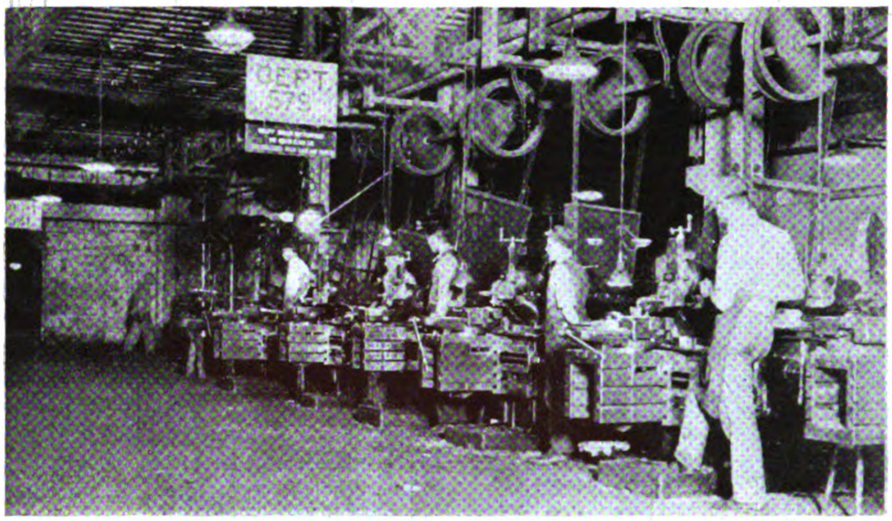
A good man with a torch can bend, build up, weld, cut, and shape up a part to replace many complicated castings much quicker and more economically than patterns and castings can be made, especially for a single part. Also, the substitute is stronger. Time is a very important element to consider in machine repairs, and often it would take too long to send to the manufacturer for duplicate parts. The welders have their oxygen and gas tanks mounted on two-wheeled warehouse-type trucks so that they can be taken to any job. The welder with a helper can handle the truck or it can be fastened to a tractor or trailer and pulled anywhere about the plant.

Gear teeth are built up when broken if the gear is large enough to make it worth while. However, we

Organization chart of the maintenance section work, Body Division.

All of the work done by this department is in connection with the Body Division of the South Bend plant, except the woodworking and sheet metal divisions; these two do the necessary work in their line for all the South Bend plants. The Chassis Division has a similar organization with the exception that it does not have any carpentry or sheet metal division.





One section of the machine and tool repair shop.

All machines of the Body Division are overhauled, repaired, and rebuilt, if necessary, in this department. The repair shop contains a complete machine shop with a large number of bench workers as well as machine hands.

maintain a stock of substitute gears on woodworking and some other machines. These are obtained from the manufacturer and kept in stock. Non-metallic pinions on the motor drives of the woodworking machines have reduced gear wear to a large extent.

To date, an arc-welding unit has not been installed. For work requiring this kind of welding a local contractor is called in. This work consists mostly of locomotive boiler repairs.

The woodworking department in the Body Division requires a considerable amount of saw filing and knife grinding. This work is taken care of in a separate division of the machine repair shop. Four saw filers and one knife grinder are employed on this work, practically all of which is performed on automatic machines, which must, of course, be set very carefully. The remaining men employed in this department are semi-skilled machinists, bench hands, and helpers.

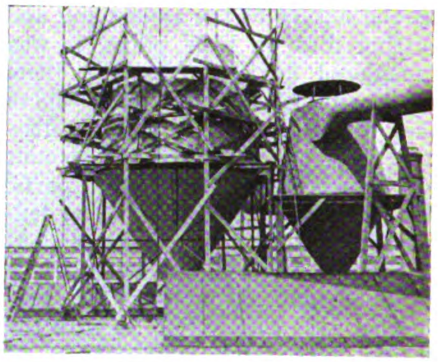
Another specialized line that is taken care of by the machine repair department is the maintenance of the high-pressure hydraulic system. This consists of one 4-in., double extra-heavy pipe line under a pressure of 2,000 lb. per sq.in., and one 4-in., extra-heavy pipe line under a pressure of 500 lb. per sq.in. During the past five years only three or four joints have let go, a record that may be attributed to the special care and supervision given in connection with their installation. These high-pressure lines are used on the body panel forming presses; the lower pressure is used to close the die, and the higher pressure is then automatically turned on to complete the forming of the parts. The highly satisfactory service of this line is one feature of which this department is very proud.

One welder is employed steadily on machine repairs.

Many machine repairs are made by building up parts from steel flats or shapes to replace broken castings. When necessary, castings are welded. The welders are shifted around in the departments as necessary. Another welder is employed on structural work.

Millwrighting.—This section takes care of the Body Division only; the Chassis Division has a separate department for its work. This department employs about 65 men, eighteen of whom are elevator operators. Elevator inspection, operation, mechanical repairs, and all the other work of the department are under the direction of the millwright foreman. Electrical work is taken care of by the Electrical Department.

Most of the millwrighting work consists of moving and setting machinery, lineshafts, conveyors, and so on. Plants like this are continually improving their machine layout and arrangement and are making changes in product or additions to the line that necesitates many moves and rearrangements of the equipment. Although this is expensive the economy effected compensates for the extra cost and usually shows a handsome reduction in production cost. This department erects and maintains all the conveyors used in the Body Division.



This cyclone is an example of the work done by this department.

The cyclone was built in the sheet-metal shop and erected by the structural shop. Practically all of the exhaust and duct systems for the plant are built here. This cyclone is 20 ft. in diameter.

A large proportion of the machines in the Body Division are individually driven, which decreases the amount of overhead work. Some group drives with lineshafts are used. New lineshafts which are put in are 2$\frac{7}{16}$ in. in diameter and usually have ball- or roller-bearing boxes. The type of drive selected in any case depends upon the power required, type of machine, and service. Individual motor drives are especially adaptable to high-speed woodworking machines, and on a number of these frequency changers are used to increase the speed of the motor.

Even with individual motor drives much of the machinery is belted to the motor. All leather belts 6 in. or wider are made endless, and practically all woodworking belts are made endless, even in the narrower widths. Other belts are fastened with the pin-and-metal-hinge type of lacing. Practically all woodworking machinery belts are of leather. Some special fabric belts are used on the presses. Rawhide lacings and the pin-and-metal-hinge type of fasteners are used on fabric and special belts. A group of men investigate and recommend types of belts to be used on the different drives and oversee all belt purchases. Two men are employed on belt work in the Body Division.

Our belt men apply, remove, and

make up belts as required. The rebuilding and repairing of belting are done by the Byproducts Division, which has full equipment for doing this work. The belt men do no other work than belt work. All oiling done by other than machine operators is by men under the supervision of the millwright foreman employed specifically for that purpose, and they are assigned a definite amount of equipment to care for. This enables them to get fully acquainted with the work and permits of definitely fixing resposibility where failure occurs on account of lack of lubrication. These men do the oiling of all lineshafts, overhead countershafts, and the large machinery, which often have places that are dangerous or difficult of access, particularly the presses; ten men are engaged in this work. The oiling of motors is taken care of by the Electrical Department.

Woodworking Division.—All new construction work and a considerable proportion of the repairs that require high-grade carpentry are taken care of by this department. The Transportation Department also has a carpentry division and its activities will be described in another article by Mr. Sullivan.

The woodworking division has a shop containing a number of individually motor-driven woodworking tools and machines, which are listed in the box on this page, and is prepared to make any parts of wood that may be required in the plant, except parts actually used in the car. This department, in addition, does all repair work on desks, cabinets, and any parts requiring millwork or cabinet work.

The difference between this Woodworking Division and that under Mr. Sullivan may be best explained by an illustration. In case a new doorway is to be cut through a wall the masons would cut the hole in the wall, and the Woodworking Division would make the door frame and door and hang it. In case the door was knocked off its hinges and had to be rehung, carpenters or handy men from the Transportation Department would be called upon. However, if the door were damaged so that machine work must be used in its repair, it would come back to the Woodworking Division.

A large amount of the work of this department is in connection with the construction of the necessary bins, shelves, racks, benches, furniture, cabinets, special stands, trucks, and special work around the plant. One big job going through the department now consists of the remodeling of 3,000 trucks on which the bodies are built and go through the painting department. All of the special trucks or racks for holding or handling any of the parts throughout the factory are built in this department. A slight change in style or model of car often requires extensive alterations in the trucks or racks.

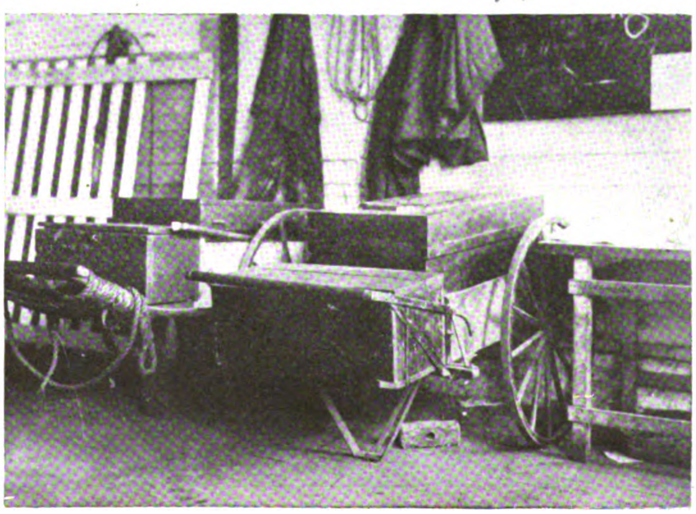
Woodworking Tools in Maintenance Shop

1 Swing saw
1 Rip saw
2 Variety saws
2 Band saws
1 12-in. Jointer
1 24-in. Jointer
1 24-in. Single-surface planer
1 4x9-in. Molder
2 Vertical single-spindle borers
1 Horizontal single-spindle borer
1 Hollow chisel mortiser
1 Radial drill
1 Drill press, 20 in.
Portable electric drills
1 Electric glue pot

Much of the woodwork turned out does not require finishing. That which does is usually stained and shellacked, or given two coats of oil. On small jobs we do this ourselves. Whenever anything is made in large quantities, we endeavor to make arrangements with the Carpenter Department to paint the parts with a spray gun. The Woodworking Division employs about 36 men. Of these, eight perform work outside the woodshop and three are machine hands. One man is a high-grade cabinet maker and the remainder are bench hands and helpers. The shop is under the supervision of a foreman.

Body Jig and Fixture Making and Maintenance.—This department takes care of the construction of all jigs and fixtures, as well as the small dies on all body construction. Whenever a new body design is brought out, it requires changes or newly built dies for many of the body parts. This department requires, in addition to its foremen, from eleven to fifteen high-grade diemakers and machinists.

Structural and Sheet-Metal Department.—The work of this department consists in doing any structural work or sheet-metal work required for both Body and Chassis Divisions. Small structural jobs, particularly those on which it would be difficult to get an outside contractor to give an estimate, are handled, if it is at all possible, by this department. Conveyors and monorails are fabricated in this department and erected



Two views taken in the millwrights' quarters.

The illustration at the left shows the storage facilities for the millwrights. These sections are entirely inclosed, although a portion of the inclosure was removed here while the photograph was taken. This department looks after the belt work as well as the general millwrighting and the lubrication of the shafting and heavier machines. The illustration at the right shows the carts each millwright and his helper have for their tools.

by the structural department and the millwrights in combination.

An acetylene welder is employed in connection with much of the work for bending, cutting, and welding, such as the installation of a conveyor line. Roller conveyors—that is, the rolls and the side pieces—are assembled in the structural shop and the supports cut from angles or flat stock. Sometimes these supports are bolted together; often the length of conveyor is laid out, blocked in position, and the supports welded on, because it is much less expensive and does not require such careful measurements of the parts as when they have to be riveted or bolted together.

The welders are interchanged between the machine repair department, the millwrights, and the structural shop. On big jobs additional welders are sometimes obtained from the Production Department. This is possible because the construction work in the plant must usually be done when the Production Department is not very busy. Approximately ten structural workers are employed in this department. This shop contains shears for both flats and angles, punches, drills, saws, and so on, for cutting or shaping angles or flats.

The sheet-metal department builds and installs all the dust- and shavings-collecting equipment in the plant. One cyclone recently constructed is 20 ft. in diameter. Some of the exhaust ducts are several hundred feet long. Suction and ventilating ducts from paint booths, plating and other vats, tumbling barrels, sandblasts, grinders, and so on, oil pans, drip pans, hoods for machines and all sheet-metal guards for the entire plant are also made and erected by this department. Belt guards are usually made of No. 18 gage, ½-in. mesh, expanded metal on an angle-iron framework. The angle-iron framework is constructed in the structural shop. Heavier belt guards, such as are used underneath a horizontal overhead belt to prevent its flying in case it should come loose, are usually made of No. 13 gage, ¾-in. mesh, expanded metal. Flywheel guards are made from either sheet or expanded metal.

Method of Handling Orders.—Practically all orders handled by any of these five departments are either repairs and renewals work orders or special shop orders. More than 10,000 repairs and renewals work orders were handled last year in the Body Division alone. A repairs or renewals work order is used in connection with a repair, a change in location or the alteration of some auxiliary equipment, such as a duct, conveyor, truck, and so on. The foremen originate these orders, but an order estimated to require an expenditure of more than $25 must have the approval of the general foreman. These repairs and renewals work orders are made out in quadruplicate and the original, duplicate and triplicate are sent to the general foreman for approval. The quadruplicate is held for record. If approved, the original is sent to the department that is to do the work, the duplicate to the Works Accounting Department, and the triplicate goes to the Estimating, Routing and Inspection Department, which orders any special materials required or suggests changes in the proposed design or layout for making a more economical and satisfactory construction, estimates the probable cost, and inspects the finished job when necessary. Minor jobs are handled upon receipt of the foreman's requisition without getting approval; the copies of the order follow the routine, however.

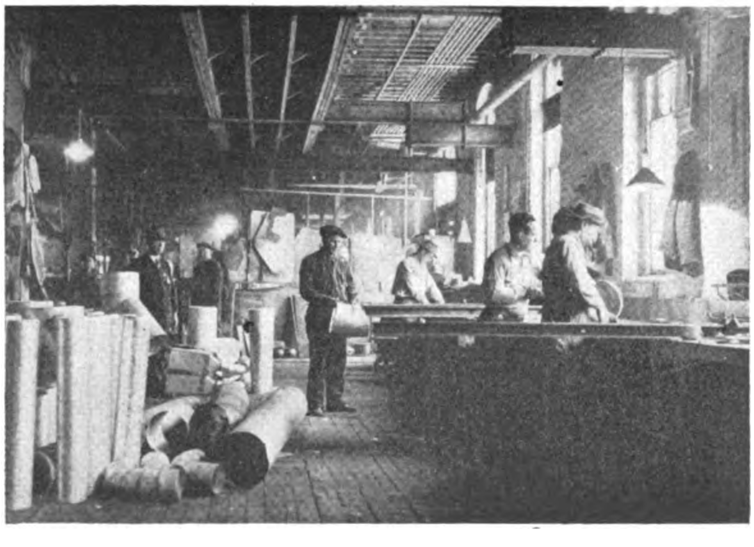
New work of a permanent nature, which would necessarily be entered into the capital account, is ordered on a special shop order. For example, the construction and the installation of a new conveyor or an exhaust duct from a paint spray booth would go on a special shop order. However, in case it were decided to move the booth, the requisition for disconnecting, moving and reconnecting the duct to the booth would go on a repairs and renewals work order. All work orders are given a special number, against which all labor and material are charged and forwarded to the Accounting Department. Materials required from stores are also charged to the same order number.

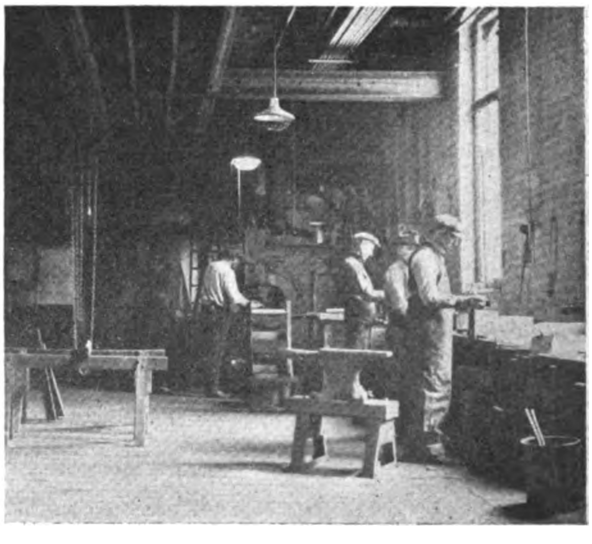
In all of this work an important point is that it should be carried on so as to interrupt production as little as possible and preferably not at all. In this way many of the changes must be made outside of regular working hours. This is not a desirable condition, but it can hardly be helped in many cases. However, the necessary overtime can be shortened considerably by having everything possible prepared ahead of time and on the job ready for the men.

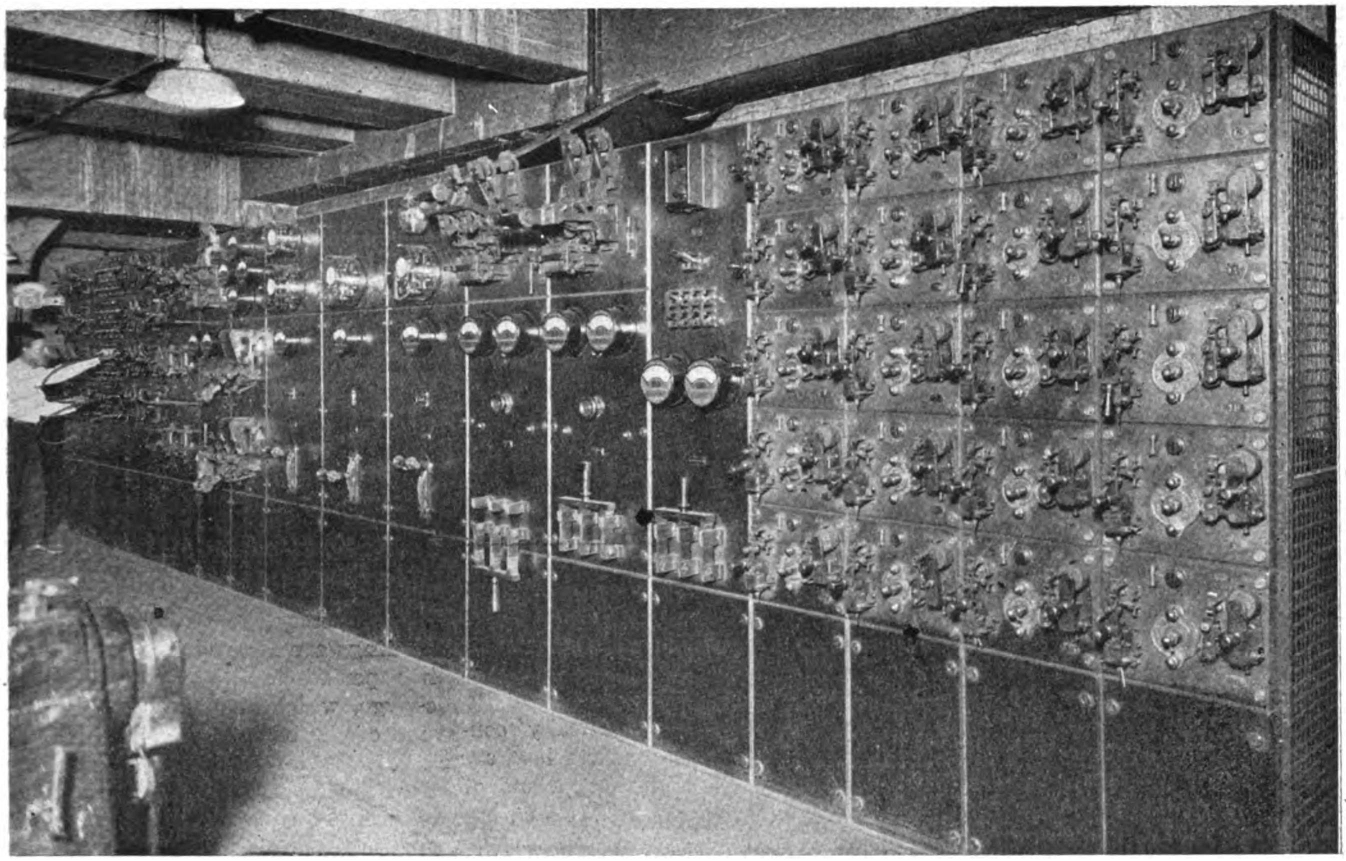
The second article, dealing with the method of handling plant maintenance, will appear in a subsequent issue.

Bench work in the sheet-metal and structural divisions.

Repairs, alterations and new sheet-metal work are also handled here. The illustration at the left shows part of a duct system under construction. The structural shop, at the right, builds conveyors, structural framework for safeguards and other miscellaneous construction. The sheet-metal and structural shops are in the same room, but across the aisle.







Charging control and switchboard at the Chicago Union Station.

Provision is made for charging 20 truck batteries at a time on the Allen-Bradley modified constant-potential control equipment, which is mounted on the four panels at the right. Another panel, near the operator at the left hand of the board, is used for controlling car-battery charging on trains while standing at the station.

Inspection and Maintenance Routine that keeps

Storage Battery Trucks and Tractors

in service

By W. LANDESS
*Chief Electrician,
Chicago Union Station Company,
Chicago, Ill.*

HANDLING of baggage and mail at the Chicago Union Station is performed by a fleet of storage-battery, burden-carrying trucks, tractors and trailers. This is the fifth largest railroad station in the world and serves the Pennsylvania Lines, the Chicago, Burlington & Quincy Railroad, the Chicago & Alton, and the Chicago, Milwaukee & St. Paul. Express is handled under the supervision of the railroads and express company and the equipment used for this purpose is not under the supervision of the station, and so will not be discussed in this article. In addition to handling incoming and outgoing mail and baggage, this fleet also handles mail to and from the mail terminal, which is situated about 1,000 ft. from the ends of the ramps in the baggage room, where all mail has to enter the station from the trains. The connection to the mail terminal is made through a tunnel under the tracks.

Mail and baggage are delivered to and received from the trains on special concrete loading platforms between each pair of tracks. These platforms are 10 ft. 5 in. wide so that trucks or trailer trains can pass, and are constructed without any columns or obstructions of any kind.

This baggage and mail platform is raised to a height which makes the platform of the trailers practically on a level with the car door, and so facilitates loading and unloading.

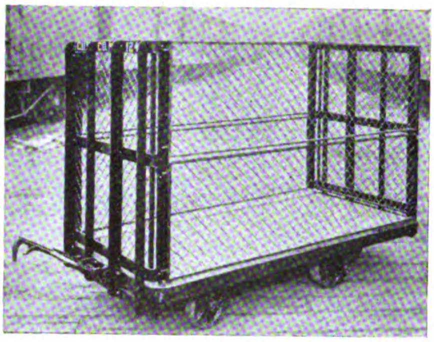
Passengers are received and discharged on another larger and wider platform on the opposite side of the train and between the next adjacent pair of car tracks. That is, there is a baggage and mail or passenger platform placed alternately between each pair of tracks. In this way, passengers and trucking are separated and do not interfere with each other. At the ends of the passengers' platform is a ramp on which they walk up and into the station. The ramps from the baggage and mail platforms extend down into the basement, which is below the tracks.

The trucks and trailers haul the mail or baggage from the end of the ramps in the baggage room either to the mail terminal or to the main baggage room. By using these ramps elevators are not necessary, which saves considerable time in

the operation of the tractors in that they do not have to wait for elevators. Also, it would require a considerably larger number of tractors because only a few trailers could be handled on an elevator at each trip. These ramps are 170 ft. long with a 6¾ per cent grade and are responsible for a large part of the severe service under which the trucks and tractors operate.

The fleet of trucks consists of 12 Elwell-Parker tractors, 8 Mercury tractors, and 8 burden-carrying Elwell-Parker trucks. In addition, 450 Mercury, type A-310 trailers, each with a permanent angle-iron and wire-netting structure erected at the ends, are used for handling mail, and 150 Highway trailers for baggage. Five of these tractors are used, together with the burden-carrying trucks, for baggage and the balance for mail.

Tractors and trailers are used for carrying mail not only because it is a long haul from the terminal to the train, but also a train of trailers permits some separation and sorting of the mailbags according to their destination, such as through or local mail, as received from the train and permits assembling of loaded trailers from different points in the mail terminal, although all the mail on a tractor train is to go on the same mail train. Practically all the mail handled out of the terminal is parcel post.



One of the Mercury, Type 310-A trailers.

These trailers are used for handling mail, generally with the sides removed. The wire-screen and angle-iron structures at the ends are built in permanently. These trailers are greased and overhauled periodically, also.

This fleet is in practically continuous operation. Batteries are changed for charging at the end of each two shifts, 16 hr., or as required. However, in practically one-third of the trucks and tractors batteries are changed at the end of each shift. Except when changing batteries the truck stops only long enough to change drivers at the ends of the other shifts.

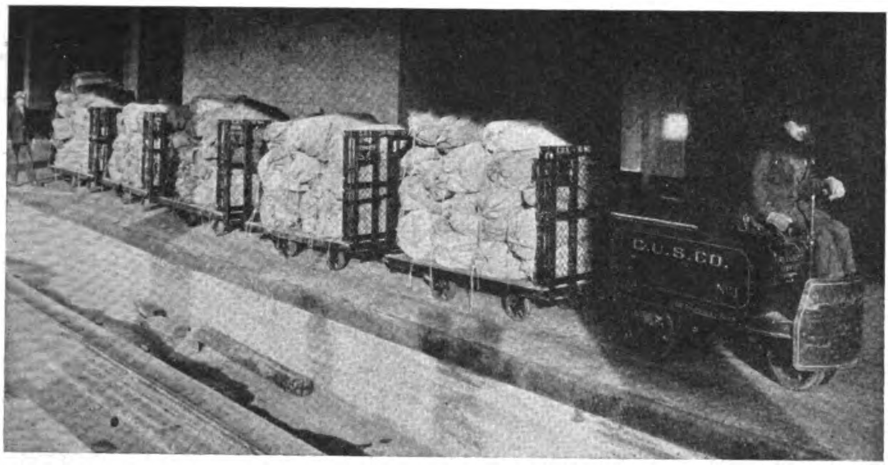
The batteries are lifted off the trucks or tractors with a hand chain hoist or a monorail. The hoist is provided with a yoke and chain, especially constructed to hook onto the battery box and place it on a hand lift-truck platform. The charged battery is lifted into position by the hoist and the truck goes back to work. While this is being done a brief inspection is made of the truck, as will be explained later. The batteries are placed in position in the charging stall by a Barrett-Cravens elevating-platform hand lift-truck. At each charging period the battery is inspected for broken cells, and to see if it needs water. Also readings are taken to determine the condition of the battery after use, and periodic readings are taken during the charging period to watch the rate of charge, which also shows the condition of the battery.

The battery equipment includes 38 Exide-Ironclad, 18-cell, 19-plate, 300 amp.-hr. lead batteries for the tractors, and 11 Exide-Ironclad, 18-cell, 13-plate, 204 amp.-hr. lead batteries for the eight burden-carrying trucks. (Additional batteries were on order to be delivered since this was written, for use in the holiday rush.) In addition two Philadelphia Diamond-Grid lead batteries and two Edison storage batteries have been added to carry on a comparison of operating costs, life and service.

Batteries are sent out for any necessary repairs because there is not enough of this work to warrant providing the necessary facilities and keep experienced battery repairmen. Most of the extensive repairs which have been necessary have resulted from an operator driving off the platform. This, incidentally, has also been the cause of most of the necessary extensive rebuilding of

Looking down the ramps from the top of the platform, above, and the lower end of a ramp in the baggage room, below.

An Elwell-Parker tractor and trailers loaded with baggage are coming up the ramp from the baggage-room. The passenger ramp leading into the station is shown on the opposite side of the empty track. Baggage and mail are taken to and from the trains upon this or similar ramps which are 170 ft. long and have a 6¾ per cent grade. It takes about 1 to 1½ mm. for a tractor to climb this ramp with a load. The platform between the trains is wide enough for trucks to pass and serve two trains. Mail coming from the trains is hauled down on this ramp and over to the left through a 1,000-ft. tunnel to the mail terminal. The door to this ramp is closed and opened by the operator by pulling on the rope, which extends down from the ceiling.



Method of handling mail at the Chicago Union Station.

This train is composed of a Mercury tractor with five trailers loaded with mail. It is interesting to note that no extensive repairs have been necessary either to batteries or to tractors, trailers, or trucks except when the latter have been driven off this platform.

trucks and tractors except one of the old tractors which had been used at the old station and was rebuilt. All truck rebuilding, however, is done in the Station shop.

The batteries are charged at 47½ volts from an Allen-Bradley modified constant-potential charging rheostat with provision for charging 20 batteries at a time. The voltage is regulated by a General Electric counter-emf. voltage regulator.

All current for this Station is purchased from the Commonwealth Edison Company and comes into the substation at 12,000 volts, three-phase, 60 cycles. Here it is stepped down on Station-owned transformers to 440 volts for some of the power service, and to 110 volts for lighting purposes. Also, five 500-kw. rotary converters are used to furnish direct current for elevators, conveyor motors, and fan motors. Direct current for charging electric truck batteries is provided by two Allis-Chalmers 75-hp., 440-volt a.c. and 50-kw., 100/50-volt d.c. motor-generator sets. Another motor generator set and a separate section of the charging board are used for charging batteries on railroad passenger cars while standing at the station before going out on a run.

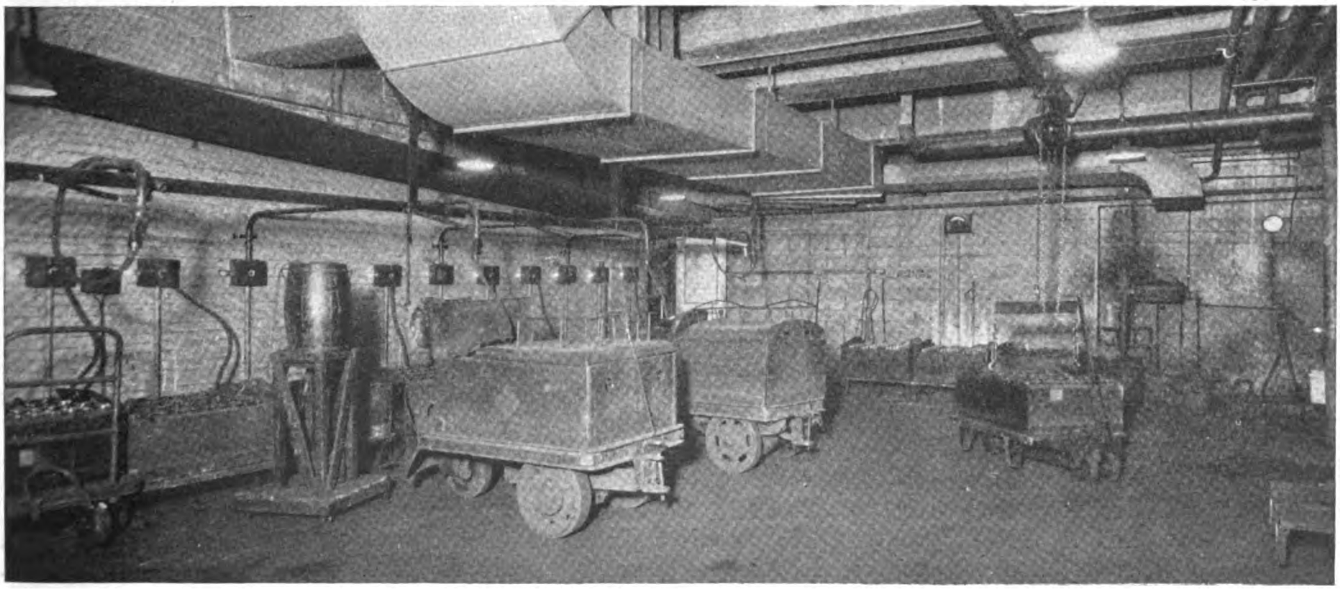
The charging of the truck batteries is very important because of the heavy load drawn from the battery when going up the ramp. A tractor under load requires from 1 to 1½ min. to make the climb. However, the batteries are standing up very well under this severe service. This is due largely to the thorough and regular inspections and proper charging.

At the same time that the battery is changed, the controller and commutator on the motor are given a careful inspection. These are the vital parts of the equipment, as the load imposed when going up the ramp will burn the controller fingers and points, especially if the truck is handled carelessly. If the controller parts were allowed to remain in poor condition, they would rapidly become worse with each trip up the ramp under load. The controllers are of the drum type and are provided with removable fingers and contact points which can be easily and quickly changed.

The commutator is inspected for pitting and cleaned after each 16 hr. of operation. These inspections take only a few minutes; for that matter they can be made while the battery is being changed, and it is believed that they have saved many hours of repair labor and have enabled the trucks and tractors to operate continuously with comparatively few failures on the job.

The men in charge are firm believers in the theory that if they wait too long to repair, they will have considerably more to repair. This is almost obvious in connection with battery, commutator, and controller troubles, but it is just as true of the other parts of the trucks and tractors.

(Please turn to page 82)



This illustration shows the battery-charging station.

Batteries are removed from the trucks by means of the hand chain hoist shown at the right. These batteries are placed on a platform and handled to and from the charging stalls by a Barrett-Cravens hand-lift, elevating-platform truck. Charging stalls are provided along three walls of the room and, in addition, a second row of charging stations is provided by extending them down from the ceiling about 10 ft. from the side wall. The Elwell-Parker and the Mercury tractors shown are both being charged from this second row. A distilled-water keg is mounted on a special truck at a sufficient height to discharge by gravity into any of the batteries. The still is along the wall, at the right in the illustration. The charging panel and switchboard are on the opposite side of the wall at the left.

Records of Accomplishment

In Reducing Operating and Maintenance Costs and Improving Plant Operation

PLANT operating executives are constantly making changes or devising plans that effect marked savings in operating and maintenance costs, or greatly improve operating conditions. Many of these plans could, with slight modifications, be put into effect in almost any plant. Other plans probably could not be adopted in their entirety, but the general principles involved might be of much assistance to operating executives in different plants who are endeavoring to solve other problems of essentially the same nature.

In order that the details of some successful plans might be recorded for the benefit of others who could make use of them, a prize contest was announced on page 575 of the December, 1926, issue of *Industrial Engineer*. A first prize of $50, a second prize of $25 and a third prize of $15 were offered for the most striking results obtained in reducing operating and maintenance costs and improving operating conditions.

In selecting the prize winners, manuscripts were judged on the general value of the results obtained from the standpoint of the savings made, the improvement in operating conditions, the soundness of the idea, the ingenuity with which it was conceived and executed, and its applicability to other industrial plants.

The first prize was awarded to O. C. Callow, Chief Electrician, Trumbull Cliffs Furnace Co., Warren, Ohio, for the work described in the following article. The manuscripts that won the second and third prizes are published on the succeeding pages.

[First Prize]

Cutting Cost of Operating and Maintaining Lighting Systems

By O. C. CALLOW
Chief Electrician,
Trumbull Cliffs Furnace Co.,
Warren, Ohio

AS THE result of much study on the subject of plant lighting, the benefits of good lighting are now generally understood. This has been brought about largely by the many good papers on the subject that have been published in the technical periodicals and by the literature put out by the manufacturers of lamps and lighting fixtures.

A rather different situation, however, seems to exist regarding the costs of maintaining industrial plant lighting systems. What should it cost per outlet to maintain our lighting equipment? What should be the average life of a lamp in our plants? What is the relation between the number of lamps installed and the number of replacements required per year? These are questions which may be asked of any industrial plant maintenance executive by his superior. But how many can answer this question with any degree of accuracy? There seems to have been very little written on the subject, as was found by the writer when he wished to determine how his lamp costs compared with those in other plants.

Inasmuch as no data were available on this subject it was decided to make a careful study, with the object of cutting down the cost of lamp renewals and securing reliable data which could be used by other industrial plants. It will readily be understood that a direct comparison of the lighting costs of two entirely different types of plants, for example, a coke plant and an automobile factory, would be misleading, but it is felt that by classifying the different types of plants some very useful information could be procured.

The plant in which the figures given later in this article were secured consists of a modern 600-ton blast furnace with power house, boiler house, machine shops, pump house, and ore-handling equipment, and a byproduct coke plant with one battery of 47 ovens, coal- and coke-handling equipment, byproduct department, motor fuel buildings, general offices, and so on.

Available figures showed that for the year 1924, 5,200 lamps had been used, representing a cost of approximately $2,700, which was considered the starting point of our investigations. Our aim was to reduce this figure. A survey was made of each building and the number, type, wattage, and voltage of all lamps used were listed. Orders were issued that all lamps replaced should be carefully charged out to the departments where they were used, and the storeroom was instructed to turn in a report each month to the Electrical Department.

Starting out with these data on hand it was an easy matter to find out just where our heaviest consumption was, and to check these points as improvements were made. Each case of heavy replacements was studied by itself and it was found that practically all of these cases

could be traced to one of the following five causes:

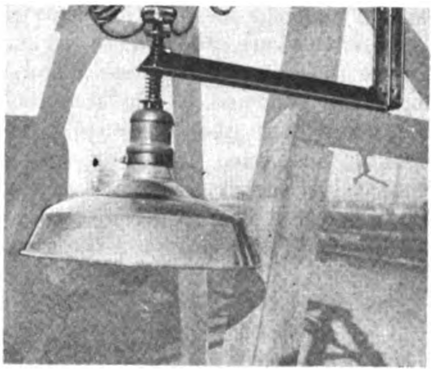
(1) Mechanical breakage
(2) Vibration
(3) Overvoltage
(4) Theft
(5) Continuous burning

Mechanical Breakage—By mechanical breakage is meant actual breakage of the lamp globe or filament by rough handling or carelessness. Most of this breakage was found to occur to lamps used on extension cords as hand lamps. By equipping all of this class of lamps with a strong, small lamp guard and seeing that no lamps are used without a guard, we were able to effect a distinct saving. The 50-watt, mill-type lamp was standardized for all portable work, as this lamp has been designed as to both globe and filament to withstand rough handling and shocks. Portable lights are used only on the 115-volt circuit, whenever possible, and the use of lamps larger than 50-watt rating is not permitted. We have found it preferable to use two or three extensions in place of one large lamp. This practice also has the advantage of making it necessary to stock only one size of lamp guard for portable lights.

In places where lights have to be mounted in low positions, where there is danger of mechanical breakage, a strong guard is now provided for them.

Vibration—Vibration is probably one of the most important causes of short life of lamps; it is also one of the hardest conditions to remedy, as wherever we have machinery running in a building there is some vibration present. There are two chief forms of vibration which affect lamps: one is experienced on moving machinery such as cranes, ore bridges, and the like, where the vibration takes the form of severe shocks due to stopping and starting the equipment. The other is a steady vibration which may be caused by high-speed machinery mounted in structural steel buildings. Both are very injurious to the filaments of lamps and cause considerable expense for replacement in many plants.

The lower the voltage for which the lamp is designed the stronger we find the filament to be, for a 500-watt lamp designed for 100 volts will have a resistance of 20 ohms, whereas the same sized lamp designed for 250 volts will have a resistance of 125 ohms. For this reason much longer life can be obtained from lamps if they are operated at a low voltage, especially if vibration is present. This is fairly easy to accomplish in building lighting, but in a large number of cases it is impracticable on cranes which are operating on a 250- or 500-volt d.c. circuit. In this case two extra hot rails would be required to pick up the low-voltage circuit. The lamps might be connected in series, using lower voltage lamps, but again we have the disadvantage that if one lamp burns out the one in series with it also goes out, which is sometimes dangerous and always calls for replacement at once. Also, both lamps have to be tested to find the faulty one. The writer has found that series lighting on cranes and ore bridges is not to be recommended.



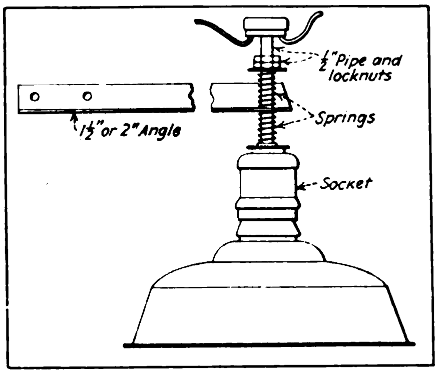
Here is a simple and effective spring hanger for large lamps.

The simplicity of construction is well shown in the drawing at the right. Old automobile engine valve springs are used to cushion shocks and vibration. The hole in the angle iron or other supporting number should be large enough to allow ample clearance for the ½-in. pipe supporting the lamp and reflector. This hanger is suitable for crane or ore bridge lighting, where the lamps are subjected to considerable vibration and shocks.

In some special cases where three or four lamps of large wattage are sufficient to light the work under a crane, good results have been obtained by using standard, 110-volt lamps with a resistor connected in series with each lamp. These resistors were similar to space heaters and were mounted on the wall of the cab, a separate circuit being run for each lamp. If the resistors are liberally rated their life will be indefinite, and their cost is only about that of the lamp they are used with. Of course, this method is rather wasteful of power, but as a rule this feature is not of so much importance.

The spring hanger, if designed correctly, will also do much to help keep down lamp replacement. There are many of these hangers on the market, some of which will give excellent results. It is suggested that extra-flexible wire be used for connecting up the lamps when using hangers of this type, as we have found that the constant swinging of the fitting will soon break off solid wire, causing grounds.

A very successful hanger has been made up by the writer and used on cranes and other equipment, where there is considerable side swing due to stopping and starting. This hanger is shown herewith and consists of two fairly weak automobile valve springs, which may be obtained from any junk yard, placed above and below the supporting member, which may be a piece of angle or strap iron, or pipe flattened at the end. The lamp socket is fastened to a piece of ½-in. pipe which passes through the supporting piece with plenty of clearance. Adjustment of the spring tension is taken care of by locknuts on the top of the pipe. This hanger was first designed for two lamps on the man trolley of an ore bridge where considerable trouble was experienced; lamps were not lasting 24 hr. After the hangers were installed and 120-volt lamps put in, the first two lamps burned over 1,000 hr.



It is sometimes advisable to keep lamps burning continuously where excessive vibration is encountered, as the filament when hot is more flexible and not so easily broken as when cold. Of course, the useful life or night life of the lamp is reduced, but breakage is cut down and we have found in our experience that an actual saving could be effected in this way.

Overvoltage—Overvoltage is much more detrimental to lamps than is generally realized and for this reason every effort should be made to insure a steady voltage supply for mill lighting. Whenever possible the lighting circuits should be sep-

arated entirely from power circuits. It is best practice to use a separate 110-volt, a.c. lighting circuit which should be connected to the steadiest source of supply available through the necessary transformers.

If the lights are connected to d.c. power circuits from which cranes, hoists and so on are operated, quite a large variation in voltage will be noted. The line voltage may, in fact, go even higher than the voltage at the generator terminals, due to the motors themselves boosting it when, under certain operating conditions, they act as generators.

Table I will be of interest, as showing the effect of overvoltage on the life of lamps.

It will be seen from this table that if we have a lamp designed to operate at 100 volts, and apply 100 volts to its terminals we get the best results, or 100 per cent. If we increase the voltage on this same lamp to 110 volts we will get over 40 per cent more light from it, but we will obtain only one-fourth of its normal life. On the other hand, if we reduce the voltage to 97 we will lose 11 per cent of the light, but increase the life 58 per cent.

The writer is operating his lighting circuits at 115 volts, a.c., but as there is a tendency for it to rise to 118 volts at certain times of the day when the load at the power house is changed, 120-volt lamps are purchased. Since changing from 115-volt to 120-volt lamps, an improvement has been noted in lamp life and this is one of the means used to keep down lamp renewals. It is, therefore, suggested that a recording voltmeter be placed across the lighting circuit feeders and a careful check made of the actual voltage at which the lamps are operating. All new lamps should then be bought to suit this voltage.

Theft—Here again we have a condition which will run up our lamp replacements, and which is difficult to overcome. Theft of lamps is found to be worse in the smaller wattage class, below 100 watts, which, of course, is the cheapest lamp to replace. For this reason if we use a large-sized lamp with suitable reflector, wherever possible, we will eliminate some loss by theft. Furthermore, the manufacturer will, for a very small additional cost, stencil on the lamps, the word STOLEN in large letters; this will prove an effective method of keeping some men from removing them.

A system can be worked out by which only the men in the electrical department are allowed to replace lamps and the old, burned-out lamps must be returned to the stockroom before a new one is issued. The writer has tried locked-on guards and locked sockets, but without very good results. If a man wants a lamp badly enough he may ruin the guard as well as take the lamp, or may break the lamp in trying to force it out of a locked socket. In either case the lamp is lost. Another disadvantage of a locked guard is that the man who changes the lamp may lose his key and in the hurry to get the job done may injure or destroy the guard; whereas if the guard screws on he is sure to have the tools needed to take it off and replace it in the proper manner.

Continuous Burning — This is simply a matter of keeping those lamps turned off which are not required in the daytime, except as stated above, where severe vibration may make it advisable to keep them burning in order to obtain longer life. By correct arrangement of circuits and switches many lights which are now allowed to burn may be switched off in the daytime. Often a whole building is lighted up so that one dark corner may have sufficient illumination. Furthermore, if the windows are kept clean lights which are now needed can oftentimes be switched off. Keeping windows clean is, however, quite a problem in itself.

There is another place where improvement can be made: namely, in danger and signal lamps. The writer has installed a number of signal lights to show when certain motors are running. These lights are controlled by an interlock on the main clapper of the control board and are operated on a 250-volt circuit. It was found that the life of these lamps was very short, owing to continuous operation and varying voltages. As ruby lamps were used the amount of light emitted was of little consequence; therefore, it was decided to place a small resistor tube on each control panel in series with the signal lamp.

This resistor was designed to reduce the voltage on the lamp to 90 volts, and a 50-watt, 120-volt ruby, mill-type lamp was used. Since the voltage on the lamp was reduced 25 per cent, and we have seen from Table I that a 5 per cent reduction of voltage will double the life of the lamp, it can be understood that these lamps now last practically indefinitely. The cost of the resistor tube and labor for installing them was about equal to the price of three lamps, and many more than these were saved in a year on this installation. This arrangement has another advantage: With the 250-volt lamps the operators did not know whether the lamp had gone out due to the motor stopping, or had burned out. This resulted in considerable confusion. Now they know that when a light goes out, it means that the motor has stopped. This system has been used in several places where danger lights are used, as on hot rails and so on, with equally good results.

The results obtained by the changes mentioned above are clearly shown in Table II. Commencing with the year 1924 we find that 1,362 lamps were installed and 5,200 lamps used at a total cost of $2,720, giving a cost of $2 per light per year for replacements, with an average change of once every 96 days. Referring to 1926 we find that 1,456 lamps were installed, and 3,795 lamps used at a total cost of $1,800, giving a cost of $1.24 per light per year, which represents a saving of 38 per cent per light. The average fre-

Table I—Effect of Voltage Variations on Tungsten Filament Lamps

Volts, Per Cent	Candle Power, Per Cent	Total Watts, Per Cent	Watts per Candle, Per Cent	Current, Per Cent	Life, Per Cent
95	83.1	93.2	111.0	97.0	216
96	86.3	93.7	108.7	97.6	185
97	89.6	95.3	106.3	98.2	158
98	93.0	96.9	104.2	98.9	136
99	96.4	98.4	102.0	99.4	117
100	100.0	100.0	100.0	100.0	100
101	103.6	101.6	98.0	100.6	86
102	107.4	103.2	96.1	101.2	74
103	111.2	104.8	94.2	101.8	64
104	115.1	106.4	92.5	102.3	56
105	119.0	108.0	90.8	102.8	49
110	140.3	116.3	82.9	105.7	25

Table II—Results Obtained by Improving Conditions Under Which Lamps Are Operated

Year	115 Volt Lamps					250 Volt Lamps			Special Lamps	Total
	50 watt	100 Watt	200 Watt	300 Watt	500 Watt	50 Watt	100 Watt	500 Watt		
1924										
Total lamps installed	....	....	....	....	....	....	....	....	....	1,362
Total lamps consumed	....	....	....	....	....	....	....	....	....	5,200
No. changes per year	....	....	....	....	....	....	....	....	....	3.82
Av. life, days	....	....	....	....	....	....	....	....	....	96
Av. life, hours	....	....	....	....	....	....	....	....	....	960
Approx. cost replacements	....	....	....	....	....	....	....	....	....	$2,720
Cost per outlet	....	....	....	....	....	....	....	....	....	$2
1925										
Total lamps installed	356	516	195	64	62	110	43	24	50	1,420
Total lamps consumed	972	1,512	480	196	144	678	168	120	160	4,430
No. changes per year	2.73	2.93	2.46	3.06	2.32	6.16	3.91	5	3.2	3.12
Av. life, days	136	121	147	120	157	59	93	73	120	121
Av. life, hours	1,360	1,210	1,470	1,200	1,570	590	930	730	1,200	1,210
Approx. cost of replacements	....	....	....	....	....	...	...	...	.....	$2,200
Cost per outlet	....	....	....	....	....	...	...	...	.....	$1.54
1926										
Total lamps installed	367	522	210	69	66	95	42	24	61	1,456
Total lamps consumed	960	1,240	342	190	115	564	164	116	104	3,795
No. changes per year	2.60	2.37	1.63	2.75	1.75	5.9	3.9	4.83	1.70	2.61
Av. life, days	140	152	224	132	208	62	93	75	214	140
Av. life, hours	1,400	1,520	2,240	1,320	2,080	620	930	750	2,140	1,400
Approx. cost replacements	....	....	....	....	....	...	...	...	.....	$1,800
Cost per outlet	....	....	....	....	....	...	...	...	.....	$1.24

quency of changing lamps was once every 140 days in 1926.

With the increased number of lamps installed in 1925 and 1926, it will be seen that, assuming the cost per light for replacement at $2 as in 1924, there was a saving of $640 during 1925, and $1,112 in 1926, making a total saving of $1,752 for two years.

The cost of making these improvements has been small, as they were taken care of by the regular maintenance men, and has been offset by the work now saved by the difference in the average number of changes per year, which has increased from every 96 days in 1924 to every 140 days at present.

The number of changes per year is obtained by dividing the number of replacements by the number of lamps installed and this result divided into 365 will show the average life in days for each lamp.

To obtain the average hours' life of the lamps we must know approximately how many hours our lamps burn per day. This can be determined fairly closely by checking those lights which burn continuously, and those which are used only after darkness. If a wattmeter is connected in the lighting feeders so that the power used per year is known the average hours which the lamps burn can be determined by dividing the total wattage of the lamps into the average power consumption per day. Of course, this figure will be only approximate, but it will be close enough for comparison. In our case it was found that the lamps burned an average of 10 hr. per day, and the plant operates continuously 365 days per year.

We found, therefore, that the average life of our lamps in 1926 was 1,400 hr., which brings up the argument that we are burning a number of our lamps after they have passed the point of maximum efficiency, as the lamp manufacturers tell us that the efficient life of a lamp is only 1,000 hr. If, however, power is generated at the plant and a surplus is available the loss in efficiency will not mean very much.

It is interesting to note the average hours' life of the different sizes and types of lamps as shown in Table II. We find that the low-voltage lamps have a much longer life than the 250-volt lamps. The reason for this was explained before: the latter type of lamp is used only on machines where the expense of installing extra hot rails would be prohibitive.

It may be thought that too much time has been spent in saving a few lamps, but it is the writer's opinion that a careful investigation of most plants will show that a considerable amount of money can be saved on lamp replacements. In a large plant it would pay to put a man on this work exclusively, giving him a free hand and a certain figure to work to. The writer has set the cost of lamp replacements for the year 1927 at $1,500, based on the same number of lamps installed as at present, and has every reason to believe that this amount will not be exceeded.

[Second Prize]

Improving Operation of Byproducts Coke Plant

By A. L. BINGHAM*

Ironton, Ohio

ONE of the most difficult problems that confront the operators of a byproduct coke plant is to hold a uniform pressure on the hydraulic gas main. The pressure setting called for ranges from 1 to 5 millimeters of water pressure, but this setting should vary not more than 1 to 2 mm. This is a matter of great importance in securing efficient operation.

Until recently we had in operation in our byproducts plant a type of regulator which was far from being sensitive. It was a motor-driven conglomeration of gears, clutches, magnets and brakes, together with a series of solenoid-operated contactors to energize the magnets which in turn actuated the proper clutch to give the desired direction to the butterfly valve which controlled the pressure. To insure ample lubrication the regulator proper was immersed in a tank of engine oil. The regulator was driven by a ¼-hp., 250-volt, shunt-wound, d.c. motor which ran 24 hr. a day. The motor was connected by a silent chain to a short, ⅝-in. lineshaft in the motor cabinet, which in turn was coupled to the machine proper through a split coupling. Power was then transmitted through a worm gear reduction to the clutches which determined the direction of rotation.

Due to its complicated construction this machine was very unreli-

*Mr. Bingham is Chief Electrician of the plant in which the work described was done. The name of this plant has been withheld at the request of the management.

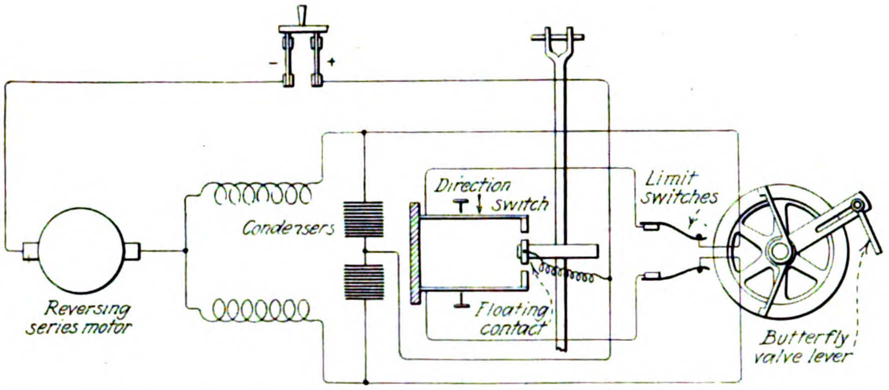


Fig. 1—This shows the method of connecting the motor and control mechanism of the redesigned hydraulic main pressure regulator.

able. It was necessary for the maintenance man to spend from 1 to 3 hr. daily keeping the machine going, in order to maintain a pressure which even then varied 4 or 5 mm. In operation, when it did operate, it was sluggish; perhaps it would open up and not close, causing a suction which created very undesirable operating conditions. Again, the regulator would close and then fail to open, causing an excessive pressure on the block.

Regulation finally became so poor and conditions so bad that inquiries were made of a well-known control manufacturer for prices on three new-type regulators, which were quoted at about $2,500, but with no assurance of perfect regulation.

In view of this, I decided to make the following changes: (1) Remove all magnets, clutches, countershafts, gears and all other unnecessary parts. (2) Make the shaft driving the lever arm worm gear continuous. (3) Make the motor reversible.

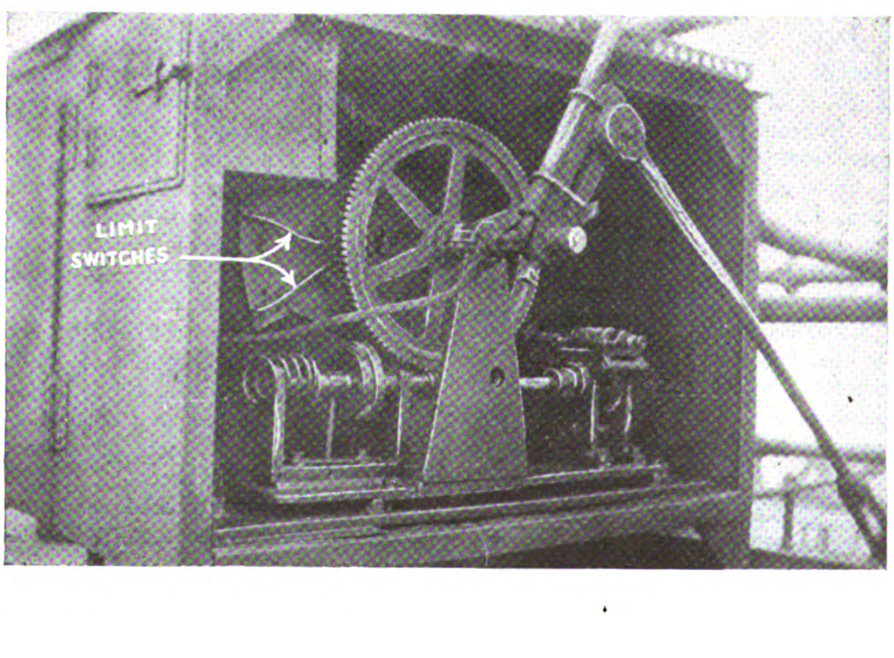
The regulator originally had two sets of contacts, each contact being made in two places, together with a set of contacts operating relay coils that closed the main contacts. Thus it was necessary to close three contacts before the magnet coils could operate the clutch lever.

I redesigned the machine to have as few contacts as possible: only one for each direction. Also, it was decided to change the motor to the series type, having two sets of coils, designed much like the motor described by A. C. Roe on page 590 of the December, 1926, issue of INDUSTRIAL ENGINEER.

Fig. 1 shows the connection of the motor and contacts, or direction switch. The motor, which now runs only when the contacts close, was left in its original place and connected in the same manner through a silent chain to the lineshaft. The shaft extends through the cabinet to the compartment where the regulator proper, which is shown in Fig. 2, is installed.

Fig. 2 shows the regulator as it looked after being rebuilt. There was originally a magnet-operated brake at the left end of the shaft, which was replaced by an adjustable, spring-tension brake which is rather sensitive, making it necessary to decrease the tension in cold weather and increase it in hot weather.

Fig. 2—How the pressure regulator looked after it had been redesigned as described in the text.



The limit switches, shown just above the brake, control the distance which the butterfly valve lever can travel in either direction. These switches were not disturbed other than to make the proper line connections. The conduit clamped to the lever arm was added to support a signal light, which indicates the position of the regulator, day and night; further, this light goes out when the fuses have blown.

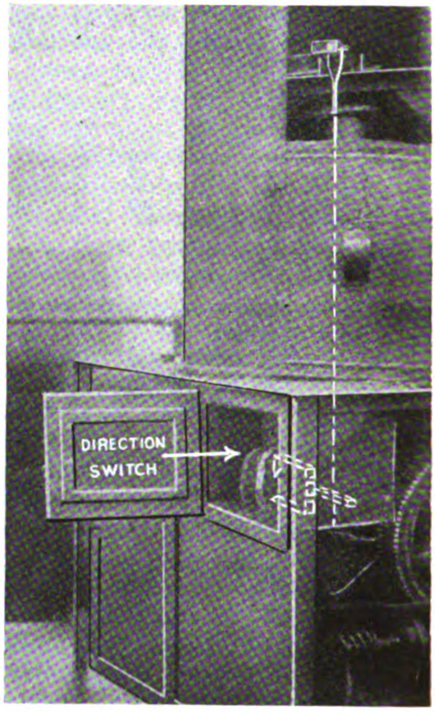


Fig. 3—The direction switch controlling the motor is actuated by the float mechanism.

In order to protect it from the weather, the float machine is enclosed in an iron tank mounted on top of the regulator housing.

The direction switch is located in the metal box which can be seen in the upper left-hand corner of Fig. 2 and in Fig. 3. It is a simple device, consisting of two adjustable, platinum-pointed contacts fixed to a fiber base, and a double-platinum-pointed, floating contact which is suspended on a rod leading up into the float mechanism. The latter is placed in a large, round tank for protection from the weather, as shown in Fig. 3.

The condensers used to absorb the current when the contacts are broken

improve operation and greatly increase the life of the contacts.

The time required to make these changes amounted to about 10 hr. for each machine; so the three machines were out of service about 30 hr. The services of one machinist, one electrician and one coil winder were required and the total cost for labor was $42.90, which compares favorably with the quoted price of $2,500 for three new regulators.

These rebuilt pressure regulators have given the following results: (1) Under ordinary conditions, a pressure variation in the hydraulic main of 1.5 to 1 mm. (2) Rapid adjustment to changes in gas flow. (3) Marked dependability. (4) Indication to operators by signal light the instant current is off the regulator. (5) Simplicity and easy adjustment.

Since these regulators have been in operation the plant has raised its coke production over 12 per cent. This has been due chiefly to better heating of the ovens, for good heating is out of the question without good hydraulic main regulation. The yields in byproducts have risen to remarkable figures, as the byproduct apparatus has operated more smoothly and efficiently under the more uniform pressure. The physical condition of the coking ovens has improved, as they are no longer subjected to such wide changes in pressure and suction as formerly.

The savings due to increased yields, greater tonnage and lower upkeep, would be difficult to estimate, but there is no question that all of these good things are due in large measure to the better performance of these redesigned regulators.

[Third Prize]

Production Delays Reduced by Eliminating Motor Trouble

By J. ELMER HOUSLEY
Electrical Engineer,
Aluminum Company of America,
Alcoa, Tenn.

BEFORE me is the card for a 15-hp., 900-r.p.m. induction motor, which has copper rotor bars riveted to a copper end ring on each side of the rotor. It is typical of many other motors on various drives and its record card shows that for some time it made frequent trips to the repair shop; now it is keeping out of the shop and staying out in the plant, where it belongs. What is the story back of this desirable change of behavior?

To consider the problem from the beginning, some of these older motors are, save for the troublesome rotors, just as good and as efficient electrically and mechanically as the newer motors with factory-welded or silver-soldered rotors. However, the trips to the repair shop were expensive. For example, it required ½ hr. for an electrician to go out in the plant and disconnect the motor: cost 30 cents. Two men, a millwright and a helper, unbolted the coupling between the motor and the pump, say, then loaded the motor onto an electric truck and coupled up the new motor: cost $3. There was another charge of $1.50 for the truck and driver, 30 cents to hook the motor up, and 20 cents for oil. By fast work the drive would be out of service only 3 hr. What the production loss may be we will not attempt to estimate, but it is safe to say that it was plenty large enough to be very annoying.

In the shop the motor was dismantled, the rotor bars and rings soldered, in the old days, with half-and-half solder and the motor reassembled at a cost of $15 for labor and materials, without "overhead." The total cost was, say, $20.30. But the repetition is what hurts.

After the motor was back in use and a good overload came on, the poor conductivity of the solder would cause it to become hot and it would be thrown off by centrifugal action. The oxidized surface between the bars and the ring is of high resistance; consequently, the speed of the motor would drop and the pump refuse to deliver the usual output, if any at all. Then the motor would have to be changed again and the whole procedure repeated.

Some time ago we were watching some workmen make repairs to the blading in a steam turbine. The wire shroud through the blade tips was being silver-soldered to the blades by using borax flux and an oxyacetylene torch. It occurred to us that inasmuch as silver is a good conductor, with a high melting point and good mechanical strength, we could eliminate our rotor trouble, if we silver-soldered the bars to the end rings. As this solder contains 70 per cent of silver we recognized the fact that it would be expensive. At the time we found it was 75 cents per troy ounce.

We bought about 25 oz. for experimental purposes and tried it out on a 15-hp. rotor. Our "gas" welder did the job in about 5 hr., the rotor bar and ring surfaces having previously been cleaned, and used 12 oz. of silver solder. In addition to the labor, there was a cost of $9 for silver solder and $2 for the necessary "gas" and oxygen.

The electric repair shop cost remained about the same. The repairmen cleaned the rotor by boiling it in a solution of Oakite Platers Cleaner for about 1 hr., or until the copper was bright, and then rinsed the rotor in hot water. The rotor dried itself in air in a short time. The cleaning tank was about 4 ft. long, 3 ft. wide and 3 ft. deep. It was raised off the floor about 12 in. and was heated by a long gas burner similar to that in a kitchen stove. The entire rotor was immersed in the cleaning solution.

After this rotor was put back in service we had no further trouble with it. Consequently, we found that by adding about 50 per cent to the cost of repairing high-resistance rotors we could end our trouble from that source and, what is more important, eliminate future production delays (which do not add prestige to the electrical organization).

Since starting this method of repairing rotors about 100 have been silver-soldered and not one has failed to perform as well as the factory-welded type. Today several companies are silver-soldering their rotors (one company adopted this practice directly as the result of our experience) at the factory, which is as it should be, for it saves the handling, dismantling and cleaning charges which come if this work is done in the field later.

It is difficult to say just what the savings have been in repair costs and production delays, but we know that they are large.

Fig. 1—This shows the view looking down the center aisle. Equipment to be repaired is delivered from an elevator that is directly behind the point from which this picture was taken. From the elevator the equipment is carried to the point at which work is to be done on it, by hand-operated monorail cranes.

Layout of an Up-to-Date Electric Repair Shop

By H. E. VAN ALSTYNE
Superintendent,
Miller-Seldon Electric Co.,
Detroit, Mich.

TO KEEP abreast of the times, to improve the quality of the service rendered and to utilize every modern method to maintain efficiency have been the policy of the Miller-Seldon Electric Co. ever since it was organized 25 years ago. That this policy has been lived up to is evidenced by the growth of the company since that time. Not so long ago it was necessary to secure larger quarters, and when these were obtained, a repair shop which we believe is a model for layout and for cutting costs of repair work was fitted out.

The general layout of the shop is shown in the floor plan in Fig. 2. All equipment to be repaired comes up the elevator shown at the left. If we assume that we are standing in front of the elevator and looking down a center aisle of the shop, we will have the point of view of the illustration shown in Fig. 1.

Immediately in front of us is the storage space for material awaiting repair. There are runways overhead for hand-operated monorail cranes that will deliver the material undergoing repairs to any part of the shop. The tracks for the monorail cranes are indicated in Fig. 2 by means of dotted lines. The tracks and the five monorail trolleys in use were made by the Louden Machinery Co., Fairfield, Ia. To the trolleys are hung chain hoists for raising the load. One of these can be seen at the left in Fig. 1. This hoist is designed particularly for lifting armatures, there being two hooks, one for each end of the armature shaft. The other chain block and trolley can be seen at the right of Fig. 7.

In general, the location of equipment is as follows:

Starting at the elevators and going down the aisle we first come to the brush making facilities at *1* and *2*, in Fig. 2, and then follow in order the cleaning booths *3* and *4*, stripping benches, dipping and baking equipment, the machine tool section, including lathes, drill-press, babbitting and arc welding equipment, special coil winding section, winding benches and the storeroom. On the other side of the aisle is the small motor repair section, the testing section, the hydraulic press, control repair section, and the coil winding department.

Carbon and graphite slabs suitable for the manufacture of brushes are carried in stock in the storeroom. The slabs are carried in the thicknesses commonly required for brushes; hence it is necessary only to cut them to size, bevel them, and drill the carbon to receive the brush pigtail. The slabs are cut to size in the brush beveling machine located at *2* in Fig. 2. This consists of a tilting table very similar to a tilting saw table. It is made by the

Hub Machine & Tool Co. Instead of a saw, it is equipped with a carborundum wheel which grinds its way through the carbon slab. For brushes ¾ in. and more in thickness, a ¼-in. thick Acme carborundum wheel obtained from the Green Equipment Co. is used. For brushes less than ¾ in., a wheel having a thickness of ⅛ in. is used. A suction fan is incorporated in the device so that the carbon cuttings are drawn off. There are steel guides on the table so that the brushes may be cut exactly to size. The table can be tilted so as to enable cutting any desired bevel on the bottom of the brushes.

The brushes are then taken to the drill press at *1*, Fig. 2, where they are drilled and countersunk. A hollow rivet is used to fasten the pigtail to the brush. The rivet is fastened by flattening and turning over the headless end by pressure, exerted through a blunt-nosed tool held in the drill chuck while running the drill at a slow speed.

Next to the brush manufacturing section are the cleaning booths. After the motors have been tested to determine what repairs are required, they are cleaned by means of a gasoline spray. The cleaning booths are shown in Fig. 3. As may be seen, they are partially enclosed and are each provided with a suction fan which draws out all gasoline vapor from the cleaning process. These booths are also used for painting the repaired motors.

Each booth is provided with two DeVilbiss spray guns, one of which (the Type A) is used for spraying gasoline while the other is used for painting. A feature of these guns is the fact that the amount of gasoline or paint sprayed is controlled by the operator by the position of the trigger. As a result he can spray as much or as little gasoline as desired depending upon the oil and dirt in the windings. After spraying on sufficient gasoline, by changing the position of the trigger of the gun, the operator automatically cuts off the gasoline and sends out air only; thus he is able to dry out the winding.

Next to the cleaning booths is the dipping room, shown in Fig. 4. There is only one entrance to this room and that is through sliding fireproof doors, which run on inclined tracks and are counterbalanced by weights. On the door end of the lines running to the counterweights is a fire link, which fuses and automatically closes the doors in case of fire. All paints and varnishes that are in cans, which have been unsealed so as to use the contents, as well as kerosene, gasoline, and other inflammable material, is kept in this room.

In the center of the room is a baking varnish tank large enough to accommodate large stators and armatures. The tank is provided with a hinged cover that is counterbalanced by a line and weight. At the cover end of the line is a fire link which will fuse and cause the cover to close in case a fire occurs. The edges of the cover fit into a special oil-filled slot around the top of the tank, thereby sealing the tank and preventing undue evaporation of the varnish. This also eliminates frequent addition of solvent. A monorail crane track runs into this room directly over the tank, as indicated in Fig. 2, so as to facilitate dipping.

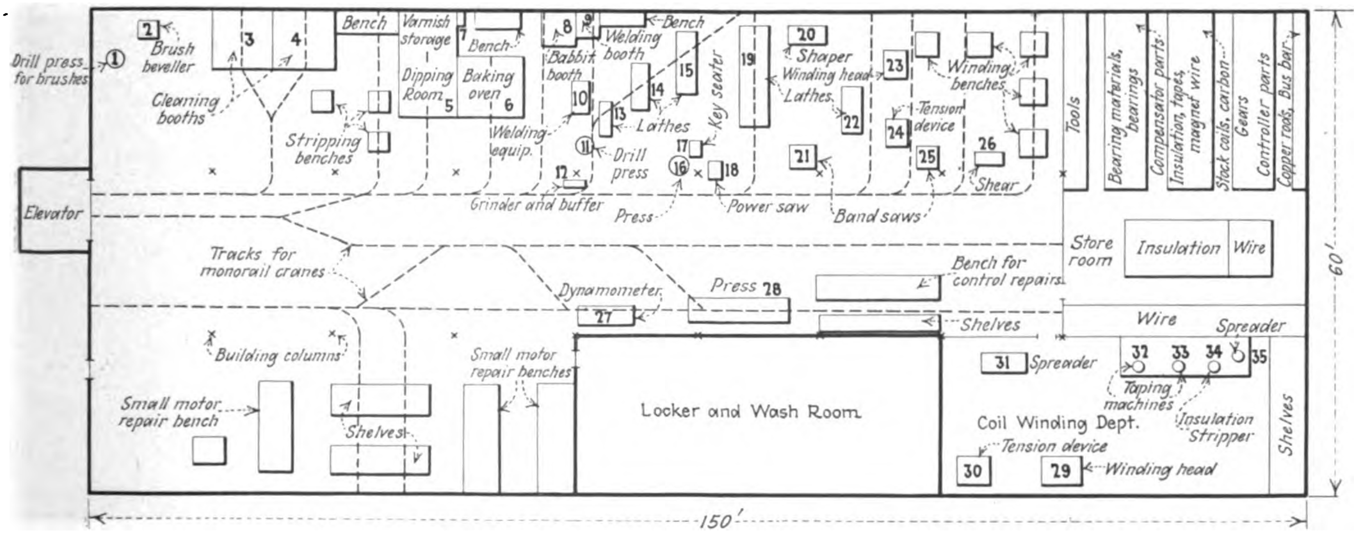
In general, all rewound motors are dipped in Berry Bros. No. 500, moisture- and oil-resisting baking varnish and baked for 8 to 10 hr. Transformer coils and other coils that are operated in oil are dipped in Berry Bros. clear baking varnish and then baked. Coils that are to be

Equipment Used in the Repair Shop of the Miller-Seldon Electric Company

1. 10-in. drill press.
2. Tilting table for cutting brushes—made by Hub Machine & Tool Co.
3. } Cleaning and painting booths equipped with De Vilbiss type
4. } A spray guns.
5. Dipping tank.
6. Baking oven.
7. Sanding wheel.
8. Equipment for babbitting bearings.
9. } General Electric, arc-welding equipment; also, oxy-acetylene
10. } welding equipment.
11. 18-in. radial drill press.
12. Grinder and buffer.
13. 8-in. lathe for bearing work.
14. 10-in. lathe } for general machine work.
15. 12-in. lathe }
16. 20-ton hand press.
17. Key seater.
18. Reciprocating power saw for cutting shaft material and structural iron.
19. 30-in. lathe for heavy machine work.
20. 24-in. shaper.
21. Bandsaw for cutting metal.
22. Lathe arranged to wind transformer coils.
23. Segur winding head for winding field and other special coils.
24. Segur tension device.
25. Bandsaw for cutting wood and fiber.
26. Shear for cutting insulation.
27. Dynamometer for testing repaired motors and generators.
28. 150-ton hydraulic press.
29. Browning armature coil winding head.
30. Browning tension device.
31. Browning coil spreader.
32. } Electric-Service Supplies Co. taping machines.
33. }
34. Insulation stripping machine.
35. Armature Coil Equipment Co. coil spreader.

Fig. 2—Floor plan of the electric repair shop, showing the location of all pieces of equipment.

Each piece of equipment is numbered, which numbers are described in the table at the top of this page.



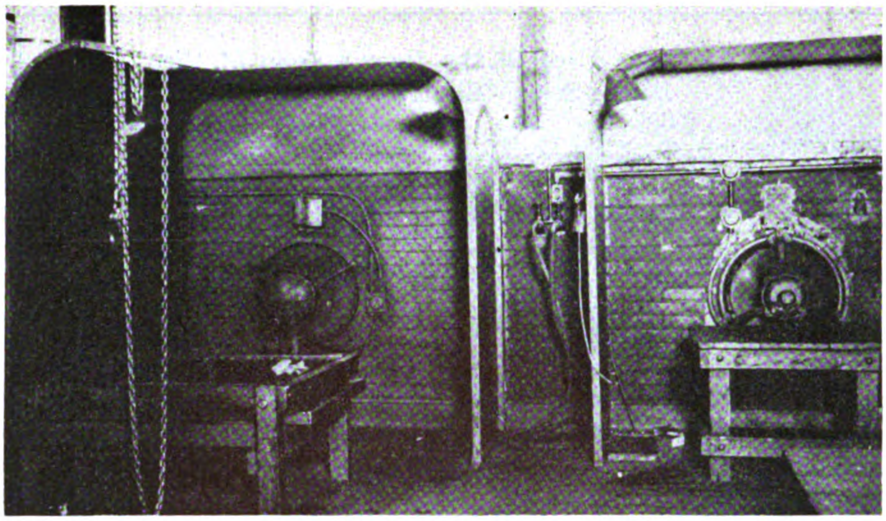


Fig. 3—There are two booths arranged for painting and cleaning.

The booth at the left is especially arranged for cleaning, having a grating on which the dirty apparatus is placed with a drip pan underneath to catch the dirt and gasoline. Between the two booths may be seen the point at which connections are made to the compressed air supply and also the control for the suction fans. Note that each booth has two angle reflectors (one at each corner) so as to give excellent illumination during the cleaning and painting operations.

used in equipment exposed to high temperatures, such as motors around baking ovens, are dipped in Berry Bros. high-heat baking varnish before baking.

All general rewind jobs after being dipped and baked are sprayed in the cleaning booths with Berry Bros. black spirit varnish. This treatment has been very successful in many installations made in chemical works where the motors are exposed to salt and alkali. After the motor has been assembled, the external iron parts are sprayed with an enamel.

Adjacent to the dipping tank is the baking oven shown at *6* in Fig. 2. The baking oven can be seen at the extreme left of Fig. 1. A crane track runs over this oven so that heavy pieces can be readily carried into the oven. The roof of the oven has a slot to permit the crane chains to pass through. This slot is closed by a special cover.

Adjacent to the baking oven is the babbitting booth, as shown at *8* in Fig. 2. This is equipped with large and small pots for melting babbitt for bearings. The booth is covered with a hood which is equipped with a suction fan for drawing off the hot air and fumes from the babbitt pots.

This same hood also extends over the welding booth shown at *9*, Fig. 2. This booth is provided with a curtain to screen the operator from the rest of the shop while making welds. Both gas and arc welding are used, and all manner of welding is done. The carbon arc method is occasionally used for cutting, but usually the oxy-acetylene method is preferred. This method is also used for welding dissimilar metals, brazing, and so on. The arc-method is used for all general welding.

A great deal of arc welding is done on the rotor bars of old motors. For this work Wilson, grade 20, bronze welding wire, 0.120 in. in diameter is used. A welding current of 100 amp. (nearly $2\frac{1}{2}$ times as great as used for steel welding) is required. A long arc (nearly $\frac{1}{2}$ in.) is drawn so as to melt the copper on the rotor before fusing the welding wire. The polarity is reversed at the welding machine so as to be the opposite from that normally used when making steel welds.

This method of welding is used on rotor bars of old rotors that have been bolted, brazed, soldered or riveted, as it is cheaper than some others and gives a permanent job. A copper ring is built up of such size as in our judgment will not materially change the starting characteristics. Rotor welding is illustrated in Fig. 5. After the rotor is welded it is placed in a lathe and the built-up ring is turned smooth. In some instances it has been necessary to make saw cuts at intervals in the end rings to increase the resistance of the rings, so as to give sufficient starting torque. This, however, does not affect the rotor bars in any way.

Adjacent to the babbitting and welding section is located the sec-

Fig. 4—Storage room for inflammable materials such as paints, varnishes, and gasoline.

In the center of this room is the dipping tank with an oil-sealed cover as shown. The monorail crane runs directly over the tank so that heavy pieces may be conveniently dipped and held over the tank to drain.

Fig. 5—Welding the bars on the rotor of an induction motor by means of the electric arc.

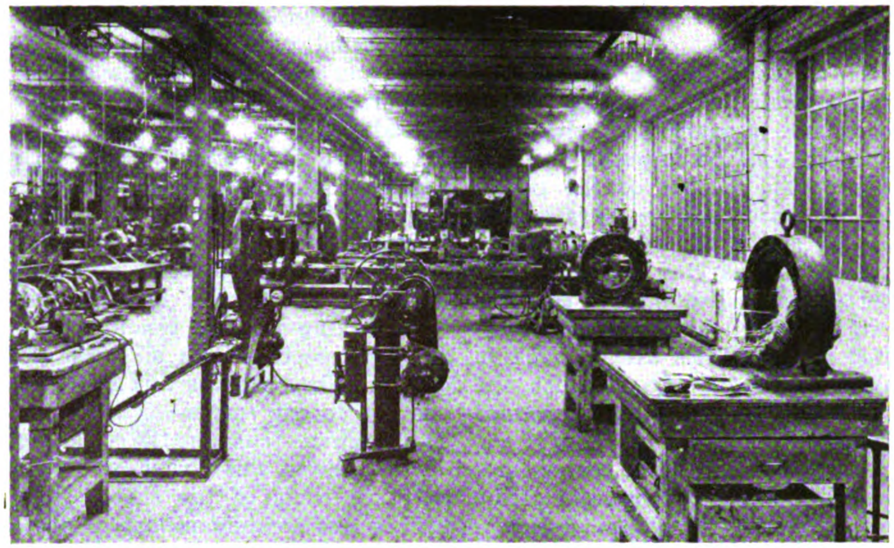


Fig. 6—Here are the winding benches and special coil winding section.

In the center foreground are shown a Segur winding head and tension device that are used for winding field and other special coils. Immediately behind is a lathe specially arranged to wind transformer coils. In the background is the machine tool section of the shop.

tion of the shop in which all machine work is done. From the floor plan layout, shown in Fig. 2, and the accompanying table it will be noted that there are located in this section four lathes, a drillpress, keyseater, slotter, grinder, power saw and two bandsaws.

Just beyond the machine section is some special equipment for winding field coils, transformer coils, and the like. This can be seen in the center foreground of Fig. 6, which is taken from the winding benches, looking towards the machine section. Items *23* and *24* of Fig. 2 are in the center foreground and two of the winding benches are shown at the right. The winding benches take up all of the space between the special coil winding section and the storeroom. The storeroom is equipped with steel shelving which enables storage of a large amount of supplies in a small space. All manner of repair parts are stored here, as will be noted from the list on the floor plan in Fig. 2.

Beginning again at the front end of the shop, the space on the other side of the aisle from the cleaning booths and the dipping room is devoted to small motor repair. The part of this section next to the locker and wash room can be seen in Fig. 7. This illustration was taken at the grinder, *12*, in Fig. 2, looking towards the dynamometer *27*. As can be seen, this section consists mainly of benches which are equipped for working on fractional-horsepower motors.

Adjacent to the small motor section is the dynamometer. This piece of equipment was made up in this shop. It consists of the generator shown at the left in Fig. 7, which is mounted on an extra set of bearings which are attached to the frame of the dynamometer. These two bearings can be clearly seen in Fig. 7. This arrangement permits the generator frame to revolve as well as the rotor. A spring scale is attached to the eye bolt of the generator frame and suspended to an upright braced against the floor. The scale and support can be clearly seen directly behind the generator. A lathe chuck is fastened to the generator shaft, thereby permitting quick connection to any motor it is desired to test.

The motor is mounted on the frame at the right-hand end of the dynamometer, as shown in Fig. 7. This frame can be raised or lowered by means of four machine screws, one at each corner. Each of these screws has a chain sprocket in the top end and a drive chain, which can be seen in Fig. 7, connects all four sprockets together. Hence when one screw is raised or lowered, the screws on the other three corners are adjusted a similar amount. Adjustment in a horizontal plane is obtained by means of the two channels on which the motor is bolted. Hence, any size of motor can be quickly lined up to the chuck on the generator shaft.

In using the dynamometer, power is applied to the motor, thereby causing it to operate and turn the generator armature. By closing the field circuit on the generator and applying a weak field, the generator develops a voltage that causes current to flow through resistance shorted across the armature. This action also develops a torque which causes the generator frame to revolve. The scale prevents it from turning, at the same time indicating the pounds torque developed by the generator. By varying the generator field current and the resistance across the armature, any desired torque up to the capacity of the generator can be developed. Hence any desired loading may be put on the

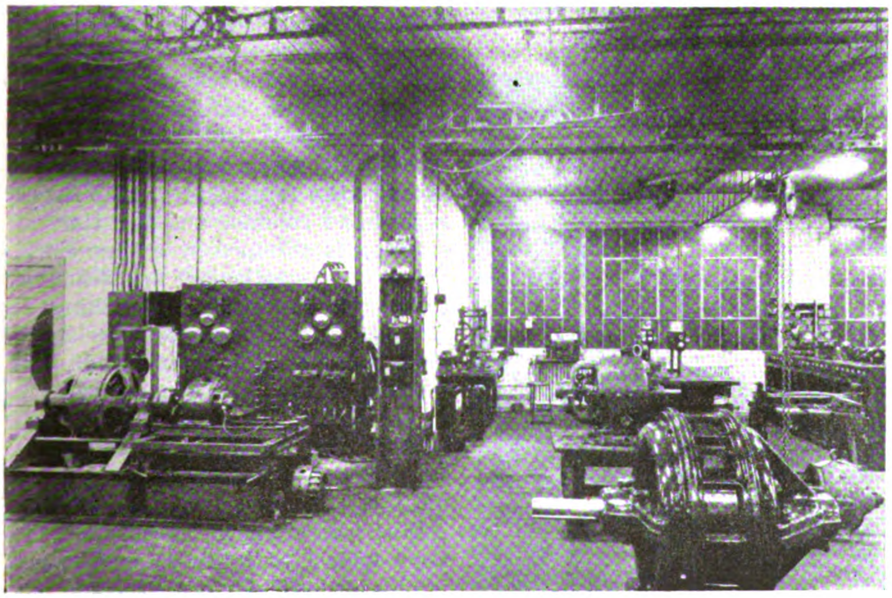


Fig. 7—Testing section and small motor repair part of the shop.

In the left foreground are the dynamometer and switchboard which are used for testing motors after being repaired. On the column in the center foreground is an arrangement of lamps and plugs with extension leads for furnishing voltages up to 2,300 volts for locating faults in motors that are to be repaired. The small motor repair section is shown in the right background.

motor and can be held at a constant value.

On the switchboard behind the dynamometer are mounted instruments for measuring the input to the motor and the output of the generator. The output of the generator is absorbed by a resistance shunted across the armature and is adjusted by varying the generator field current. Readings of the generator output and the weight indicated on the scales are referred to calibration curves from which the horsepower developed is determined directly.

On the column in the center foreground of Fig. 7 is shown one of the test points from which leads are taken to damaged motors to test them for grounds and other insulation failures.

Adjacent to the dynamometer is a 150-ton hydraulic press located at *28* in Fig. 2. This press is unusual in that it is operated by compressed air in setting up the work. This makes for speedy movement of the jack and enables clamping the work in the press by air pressure. The real pressure is applied by oil from a motor-driven pump. All heavy press work is done here, the light work being done on the 20-ton press located at *16*, in Fig. 2.

The control repair section is located next to the hydraulic press. This consists of a bench and a large section of steel shelving immediately behind it, all of which is equipped for aiding the repair of all types of controllers and accessories.

Next to the control repair section is the armature coil winding section. This is equipped with a Browning winding head, tension device, and coil spreader. A view of these machines is shown in Fig. 8. On the long bench adjacent to the storeroom are located two Segur taping machines, an insulation stripper and an Armature Coil Equipment Co. coil spreader.

Daylight is received from large windows on both sides of the building. In addition to this, related kinds of work are grouped together and the work producing dirt and dust is grouped. For instance, the brushmaking section, cleaning, and stripping sections are all close together. They produce dirt and dust and are in one corner of the room. The suction fans in the cleaning booths prevent this dust from going to other parts of the shop. Babbitting and welding produce fumes, so they are located together and provided with a suction system for handling the fumes. All of the machine tools are grouped in one location.

Likewise, the armature coil winding section is located in one corner of the room, which is fenced off by wire screening. Inasmuch as girls do a great deal of this work it affords a separate place for them to work. All of the small motor repair work is grouped together. Also, note the convenience of the dipping room to the baking oven and then back to the cleaning booth for final spraying of black varnish and enamel. Attention is also called to the excellent system of electric lighting as exemplified in Figs. 1, 6, and 7.

It will be interesting to trace the progress of a motor undergoing repair in its travels through the shop. The motor is delivered to the shop floor by means of the elevator. As soon as it is received, it is given the identification card shown at *A* in Fig. 9. A job number is stamped on both the top and bottom halves of this card and the other information called for on the card is filled in. The top half of the card is tied to the motor while the bottom half goes into the office as a record of the motor.

The machine is at once tested at one of the test points (such as the one shown on the column in the center foreground of Fig. 7) to determine what is wrong and what repairs will be needed. These are entered on the bottom half of the card and an estimate of the cost is made. If the customer decides to have the job done an order number is issued and stamped on both halves of the identification tag.

The motor is then taken apart on the stripping benches near the dipping room (as shown in Fig. 2). If the machine must be rewound, the old winding is stripped out at this same place. It is then cleaned at the cleaning booth.

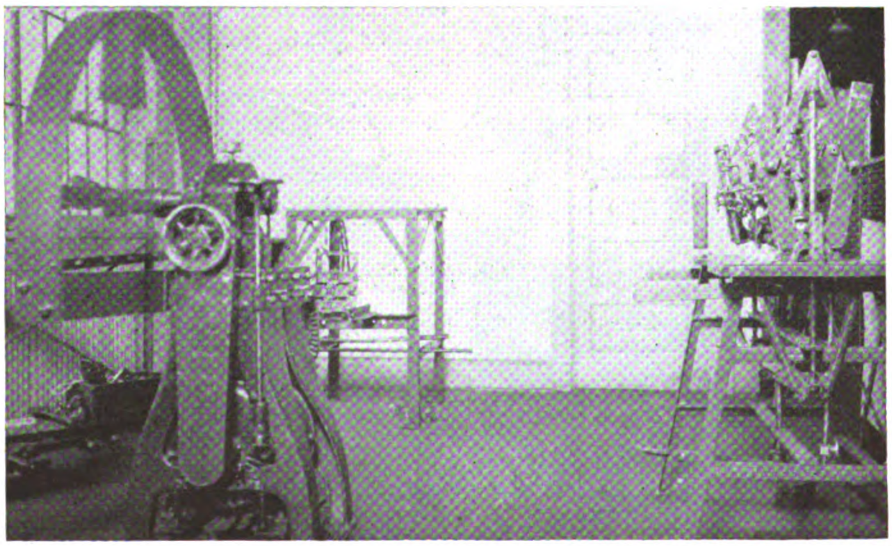
In the meantime, new coils are being made in the coil winding department and any machine work or welding required is done in the corresponding sections.

Before the winding was stripped the coil data were taken and recorded on the form shown at *B* in Fig. 9. On this same card the coil maker records the material used in making up the coils. When the coils have been made they are delivered to the winding benches near *26* in Fig. 2, and card *B* is returned to the office.

The material charged out on card *B* is entered on the form shown at *C* in Fig. 9. Each workman on a given job presents the card shown at *D* to the time clerk, who writes in the workman's name and number; the operation to be done is written in the right-hand column, and the time of starting is stamped by a time clock. When the particular operation is completed, the time of finishing is stamped on the card and the elapsed time can readily be computed. All material that is used for a given job is entered on the form shown at *C* in Fig. 9. The total material cost and the labor cost are consolidated on the "Incoming Motor and Job Record" form shown at *E* in Fig. 9, from which the total cost of the job is obtained. This form is made out

Fig. 8—This illustration shows one end of the coil winding department.

At the left is a Browning armature coil winding head and behind it a tension device made by the same manufacturer. At the right is an armature coil spreader.



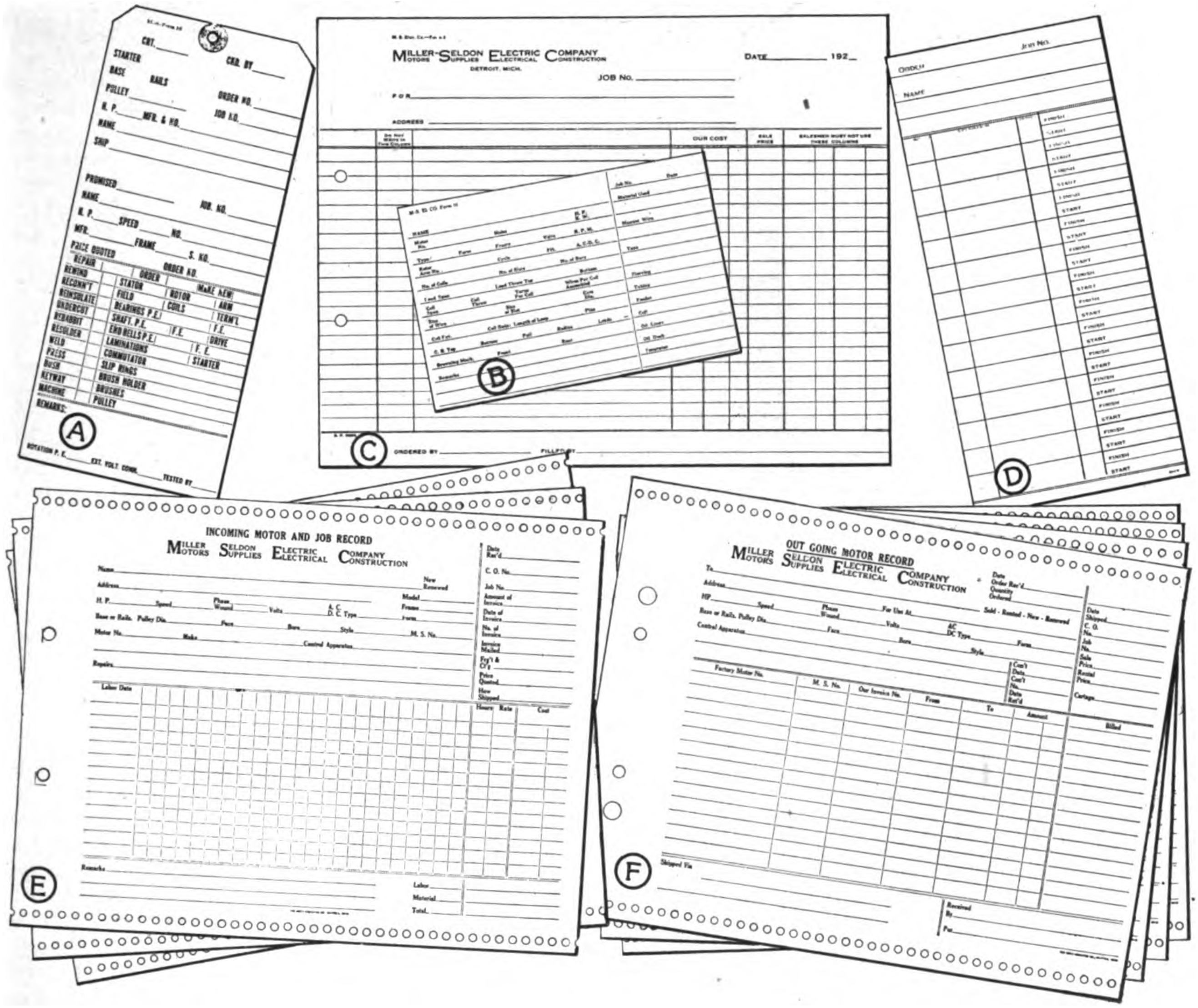


Fig. 9—Here are the forms used in recording data and costs, as well as identifying and billing a job.

As soon as a job is received the tag shown at *A* is filled out and attached to it; the bottom half of the tag is torn off and sent to the office. *B* shows the form on which are recorded the winding data. At the extreme right, space is provided for the coil maker to record the material used in making the coils for this job. At *C* is the form on which all material used is charged from the storeroom to the job. The time for each operation required on a job is put down on the card at *D*. The material and labor costs from *C* and *D* are then consolidated on form *E*, which is made out in triplicate. *F* shows the statement that is presented to the customer. Four copies of this form are made out.

in triplicate, one copy going to the shop, another to the office, and the third to the shipping department.

After the motor has been wound, it is dipped and baked and then given a coat of black spirit varnish, after which it is completely assembled and the exterior iron parts given a coat of gray enamel.

The "Outgoing Motor Record" (shown at *F* in Fig. 9) is then made up in quadruplicate; this is in reality the customer's bill. One copy goes to the shop, another copy goes to the office, the third copy is sent to the customer and the fourth copy goes to the shipping department.

Control and small motor repairs are handled in a similar manner except that they go to a different part of the shop to have work done on them.

There is one little scheme for keeping track of the parts of a motor after being taken apart, which should be mentioned. All parts of a motor, except those that are to be repaired, are stored in one bin which is marked with the job number of the motor that is being taken apart. These bins are located in the place marked "shelves" in the small motor repair section shown in Fig. 2. In this way, the parts of a given motor are kept together and do not get lost or mislaid while the motor is undergoing repair.

The distribution of the personnel required to operate this shop is very interesting. The control of the shop centers under one man, the shop superintendent, who has an assistant superintendent and two clerks to help him with the office work required. Directly in charge of the men working in the shop is a shop foreman and under him are the following:

3 men for testing
4 men for cleaning and stripping
4 girls for making coils
6 men for winding
7 to 10 men for assembling
2 men for dipping and baking
6 men for small motor repairs
1 welder
5 machinists
2 men for control repair
1 man in charge of storeroom
5 men for outside service work

This list is subject to some fluctuation, but the number of men in the shop averages 45.

Repairing motors and other electrical equipment does not differ materially from the manufacture of any product. In both cases it is important that the various operations be performed with the least amount of waste time and effort. We feel that the manner in which we have arranged our equipment accomplishes this end.

Applying aluminum paint in a Cleveland factory. Cost and other data on this particular painting job are given in the box on page 80 of this article.

Painting Practices In Industrial Plants

By FRANK E. GOODING

Associate Editor, Industrial Engineer

PRACTICALLY every industrial plant has a different policy with respect to painting the factory interior and exterior surfaces. This policy is usually a reflection of the ideas of the management in regard to good housekeeping and the value of good lighting. Generally, poorly lighted plants are also badly in need of a coat of paint, which would go far toward making brighter surroundings and permit the light striking the ceiling to be reflected instead of absorbed.

In plants which are suffering from defective production, due to carelessness and poor light, cleaning and brightening up the interior will often improve the quality of the workmanship. Poorly kept surroundings are commonly reflected in a slovenly attitude toward production. Although it is difficult to measure direct returns from painting and cleaning, the management in practically every case after a shop is brightened up attributes at least part of the improvements in quality and quantity, as well as a better attitude of the workers, to the improved appearance of their surroundings.

The article entitled, "Lighting Value of Paint in Industrial Plants," by M. Luckiesh and E. W. Commery, Lighting Research Laboratory, National Lamp Works of General Electric Company, Nela Park, Cleveland, Ohio, which appeared in the August, 1926, issue of INDUSTRIAL ENGINEER, discusses the relative reflecting value of paint and the loss of light due to the decrease in the reflecting value of the paint, through the accumulation of dirt. In this particular article it was pointed out that the monetary loss from the light paid for but lost by being absorbed and not reflected by the soiled walls would, even in the comparatively clean surroundings of the drafting room under observation, be sufficient to make it economical to repaint about every 14 mo. Conditions are much worse in most industrial surroundings where repainting schedules are seldom on less than an every-third-year basis, and more commonly at longer intervals.

The value of white paint for ceilings is so well recognized by those who believe in frequent painting that any other color is now seldom used. The question of the relative values of flat and glossy white surfaces is also so well covered in the article in the August, 1926, issue, that it will

Mill white brightens up this pressroom interior.
The paint on this interior was applied with a Vortex gun. Complicated machinery, such as shown here, increases the cost and difficulty of doing the work if scaffolding has to be built over the machines.

Much can be saved in time and cost if the building is painted before the machinery or equipment is installed.

A simple, plain scaffolding made from painters' ladders and planks is used with this two-man DeVilbiss unit. The bare floor is easily covered with tarpaulins.

not be taken up further here. The present article will deal with the painting practices of various industrial plants.

As previously stated, housekeeping is made easier by well-painted surroundings. Dirt may be allowed to linger in dark corners, but when these corners are painted white even the most careless men hesitate to spoil them, particularly if the management has shown emphatically that it intends to keep these places clean. One of the best examples of this is the now common practice of painting the corners white on stair landings, to eliminate the unsanitary habit of expectorating in the dark corners.

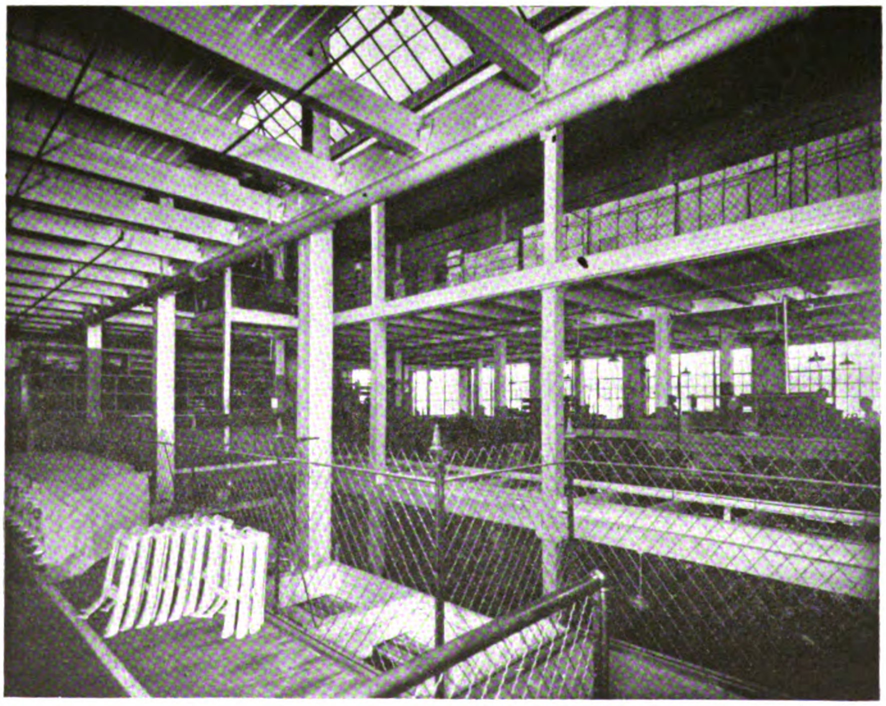
Following out this same plan one Chicago factory paints a white baseboard along the walls of the room. The remaining wall surface is battleship gray up to about 5 ft.; the ceiling and upper walls are white. Still another Chicago factory paints a similar white band around the foot of each column or post and also extends the white surface out on the floor about 10 in. from the column.

Food factories, particularly because of the careful inspections for cleanliness required under local or state regulations, are turning to washable white walls to aid them in maintaining a clean plant. Lacquers are being frequently used here, because of the large amount of cleaning which is necessary. In some cases the walls or parts of them must be washed at least once each day and are often wiped off several times a day.

For example, in a candy factory when chocolate is spattered on a white wall, it is cleaned off at once, whereas, with dark walls, on which such spots will not show, the chocolate would be likely to remain there and the walls be cleaned only at long periods, which would not meet with the approval of the inspector. The lacquer, which is in the same class of covering as the Duco finish on automobiles, will, it is stated, stand this repeated cleaning and washing. Some other types of factories are also coating interior surfaces with lacquer, so that cleaning may be done more frequently without the necessity of repainting.

Another application of aluminum paint.

Practically the entire interior of The Reynolds Electric Company plant has received one spray coat of aluminum paint. Lights are practically unnecessary on all floors except the first, during fair daylight. This light well and crane bay supplies light to the center of the building. The color scheme is shown in a box on another page.



A printing establishment painted its glue room white all over, even the floor, and all glue spots are now cleaned up before they harden. This had been a particularly difficult place to keep clean because the hardened glue could be removed from the walls only with considerable effort. Many other plants use white paint similarly to keep the rooms clean and free from objectionable marking.

When deciding on a painting plan, one of the first problems is to select a color scheme. As stated, either a mill, flat or lacquer white is now the commonly accepted color for ceilings, although aluminum paint is being used in some plants. Industrial plants differ in their practices in regard to the color used for walls. In some plants, the same color used on the ceiling is extended down almost or entirely to the floor. A more common practice is to use a darker paint for the dado on the wall, which varies in different plants from about 3 ft. to 6 ft., with a height of 5 ft. probably predominating. Battleship gray is a common and pleasing color for wall dadoes, although light and dark brown and other dark colors are sometimes used. It must be remembered that the darker the wall paint, the less its reflecting value, and walls should have some reflecting value.

Two objections are sometimes raised against using a light color on a wall: Sections within reach, which are exposed to trucking and moving of materials, become soiled

Applying a protective exterior coating with a DeVilbiss gun.

quickly and the glare from the light surface is objectionable where workers are forced to face a white wall when it is exposed to the sun or other bright lights. The latter is probably the more serious objection because the white walls *can* be kept clean, at least they are in many plants. Of course, material cannot be piled against white walls, nor trucks bumped up against them, two points which, from a housekeeping standpoint, favor the white wall.

Columns and posts, however, are frequently painted a darker color for 4 or 5 ft. up from the floor, because of the greater difficulty in keeping them clean in that they are more in the way and are also more likely to be touched with dirty hands. There is less excuse for touching a wall than a column or post.

Whether to use mechanical painting or not depends largely upon the amount of surface, its character, and the difficulty of covering up or working around the equipment in the plant. Whenever it is possible to get into an empty building, or when the equipment is not in operation, and so can be covered up without interference, mechanical painting, usually, has a considerable economic advantage over brush painting. This is particularly true of rough surfaces, such as brick, unfinished or rough lumber and so on, which are hard to brush. Aluminum paint and lacquer are more easily applied by mechanical painting equipment than by brushing.

When the areas to paint are small and so increase the amount of shifting of the tarpaulins and other protective equipment, there may come a point where the economy of the spray method in coverage is overbalanced by the increase in the cost of protection and shifting the equipment. It requires experience to be able to tell how a surface can be most economically painted. Steel sash, for example, is seldom painted with a gun. Some industrial men do not believe that it pays to paint the narrower columns between windows with a gun, although others do.

Ordinarily, mechanical painting is estimated at about half the cost of

Cost Data on Aluminum Painting

(Cleveland factory; Paasche air brushes used.)

Area coated
- First Coat: 265,000 sq.ft.
- Second Coat: 185,000 sq.ft.
- Total: 450,000 sq.ft.

Men employed
- 4 spray operators: 2 or 3 helpers part of the time; at other times none. Average 2 helpers.

Time
- 823 spray hours

Rate of coverage per gun
- 547 sq.ft. per hr.

Material
- 2,500 lb. aluminum powder @ 53c. per lb.
- 1,800 gal. bronzing liquid @ \$1.20 per gal.
- Total—\$3,583.
- This is equivalent to 0.7962c. per sq.ft. or 79.6c. per 100 sq.ft.

brush painting, sometimes more and in other cases less. Although the former often requires more paint, particularly with a less experienced operator, the labor cost is lower. Constant shifting of apparatus or protective coverings, because of broken-up wall areas, increases this labor cost. Trimming and painting of pipes and similar work is usually done most economically by hand painting; this is almost essential where the paint used is of a different color than the background.

None of the industrial concerns interviewed in connection with the preparation of this article found any difficulty in obtaining operators for their mechanical painting equipment. Some of the companies were able to take men engaged on paint booth work and assign them to a portable paint spraying outfit for building work. Other concerns pick either painters or handy men from the maintenance gang and break them in on the use of the gun. Manufacturers of painting equipment, however, complain that these men do not know how to take care of the gun, hose, and paint chambers, and so do not clean them out when they are put away after the job is finished. The man in charge of maintenance should see that this is done. The manufacturer will supply directions.

Frequently, painting is done at night because that causes the least interruption to production. For example, at a Chicago factory, engaged in light manufacturing, with most of the work performed on sewing machines, three floors, about 300 ft. long and 100 ft. wide, were painted at night by the painter with the help of the janitors for shifting the tarpaulins. In this case, canvas curtains extending to the floor were suspended by hooks from the sprinkler and other overhead pipes. These were hung so that they partitioned off an area approximately equal to a building bay; a single column, however, was in the center of the enclosed area instead of a column at each corner. The janitors also covered up any machines or stock with tarpaulins and moved the entire enclosure as necessary. While the operator was painting, the janitors went on with their other cleaning work.

Light was supplied by two portable lamp stands, the reflectors being turned upward towards the ceiling. Sprinkler heads were covered by slipping a light paper bag over them.

Exterior as well as interior walls can be repainted by the spray gun. For such exterior surfaces, it is best to use special brick or stone paint. This is a Paasche air brush job. In some places cement is mixed in with the paint as a vehicle and applied with a gun having a slightly larger opening than is used for ordinary paint.

Brightening up the interior of an industrial plant with white paint.
The difference in the light-reflecting qualities of a surface before and after painting is well shown here. Matthews mechanical painting equipment was used on this job.

It was estimated that at least 25 per cent was saved on the cost of this job by doing the work in this way instead of letting it out on contract. A painter from the maintenance gang operates the gun. He is kept busy at other times on the many miscellaneous painting jobs which have to be done in a plant of that size.

In most of the other plants visited painting is handled in practically the same way. Much can be saved by planning ways to support the curtain surrounding the area to be painted and by using scaffolds which are easily erected and shifted. Fastening the curtain to a cross-pole and then using other vertical poles to hold it in position is, perhaps, one of the quickest methods of erecting a curtain where it cannot be hung from overhead. This same plan can be used to protect a window either in the wall or in a saw-tooth roof. Horses for scaffolds can usually be built the proper height for the ceiling, or made adjustable.

The surface to be covered must be in practically the same condition for either brush or mechanical painting. Cold-water paint must be washed off. Grease spots must be removed. New work requires more coats to cover it. It is seldom advisable to try to apply an extra thick coat and make one coat do. Resinous knots require shellacking. All of the many precautions necessary with painting must be followed, irrespective of the method of application.

Aluminum paint instead of white paint is being used by a number of industrial plants for ceilings and walls. These are mostly new jobs and will be under close observation by industrial men to determine their lasting qualities, the effect of dirt, how well they can be cleaned, and other operating features.

The Reynolds Electric Company, Chicago, Ill., manufacturers of sign flashers, recently painted practically all the factory ceilings and walls with aluminum paint. A view of the plant interior is shown in one of the accompanying illustrations. This is an interesting paint job and will be described in considerable detail. The ceiling had been painted with mill white about 6 yr. previously, and washed about 3 yr. ago. The brick walls had been coated with a cold-water white paint which had to be washed off.

Color Scheme at Reynolds Electric Company

Ceiling—Aluminum paint
Walls—Aluminum paint
Columns—56-in. battleship gray dado
Inside partition—56-in. battleship gray dado
Floor lines—Egg-shell mill white
Machines—Gray oil-proof machinery paint

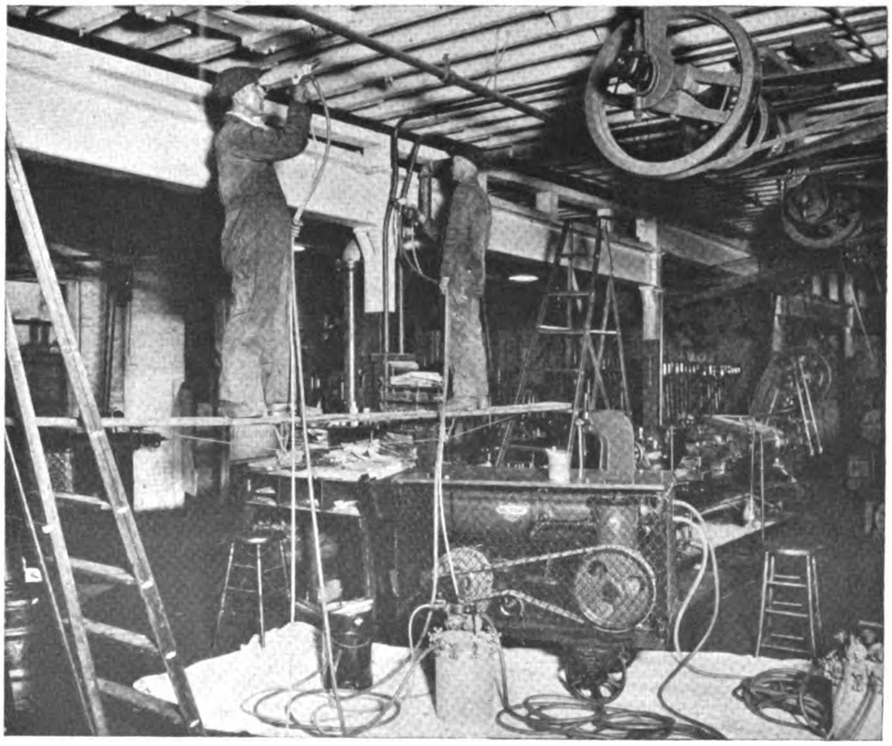
Piping Color Scheme

Hot water—Olive green
Steam returns, and radiators—Medium brown
Compressed air—Light blue
Cold water—Battleship gray
Gas—Black
Conduit—Painted same color as surface on which it lies
Sprinkler system—Bright red
Drain pipes—Light lead gray
Fire extinguisher markers—Bright red band around column on which extinguisher is mounted.

Before repainting the entire plant, two adjoining bays in the darkest part of the building were painted—one with a mill white paint and the other with aluminum paint. After a short period of observation, it was finally decided to use aluminum paint. A painting scheme, as shown in the accompanying box, was then drawn up. The operator started on the top floor and worked downward. When he was working in a section the machines were covered with tarpaulins, and sawdust was sprinkled over the intervening floor spaces. Aluminum paint is rather difficult to hand-brush and so all surfaces coated with aluminum were sprayed. A handy man was hired for this work.

The brick walls were washed to remove the cold-water paint and also had to be sized before coating with aluminum paint. The varnish, which is used as a vehicle for the aluminum paint, was sprayed onto the brickwork to form the sizing coat. In this case, the entire walls were covered

Two men working on one scaffold can quickly cover a large area.
If the floor is protected by tarpaulins or sawdust, there will be no paint spots to clean up. These operators are using a Matthews mechanical painting outfit.



On this job the painter averaged 12,000 sq.ft. per 8-hr. day.

A special Truscon protective paint was applied to this roof with a Paasche air brush.

down to the floor with aluminum paint. It was desired to keep the outside walls clean and to prevent anything from being piled up against them or in the corners. The amount of aluminum paint used each day had to be mixed daily. It is mixed in the proportion of 1 gal. of varnish, 1 gal. oleum spirits, and 4 lb. of aluminum powder.

A battleship gray dado 56 in. high was used on all partitions except on the brick walls along the outside of the rooms. Columns and posts were also given a battleship gray dado.

The floor lines for trucking aisles were painted with egg-shell mill white. In addition, all factory machines were painted with a gray oil-proof machine paint. These, of course, were hand-brushed jobs.

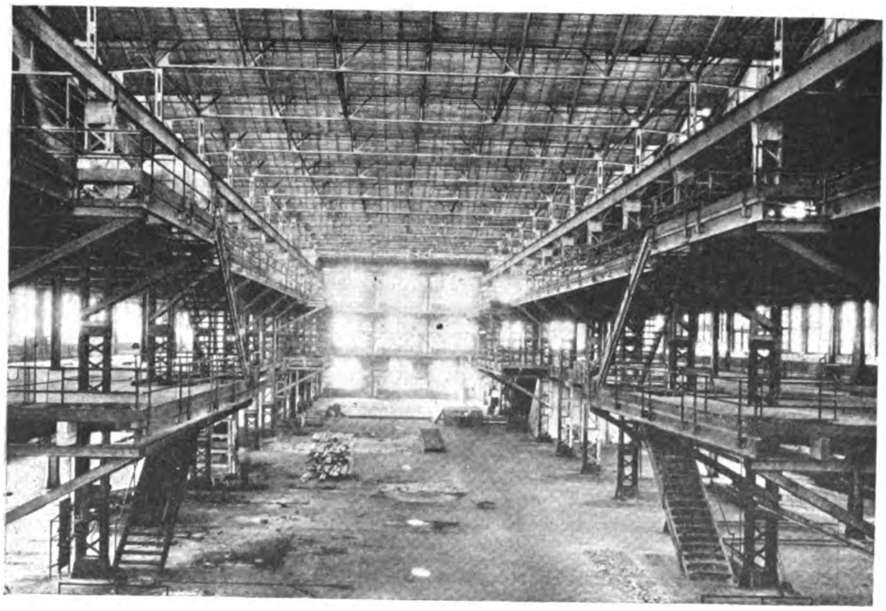
The color scheme for the piping layout is given in the accompanying box. One interesting point about the piping color scheme is that conduit is painted the same color as the background on which it lies. This item alone saved considerable in the cost of the painting because most of the conduit work lies directly on the ceiling, walls, or columns, and if it were painted a different color would necessarily be a brush job, whereas it was covered up by the gun as the ceiling was painted. The other pipe lines were all a short distance from the wall and required brush painting.

Reference to the illustration of the Reynolds factory shows a most interesting construction. The building does not have any elevators. A light well in the center of the building extends from the basement floor to the top floor and is served by an overhead crane. Platforms at the end of this light well are offset on the different floors so that the crane can deposit or pick up a load on any floor. The entire plant is practically day-lighted from this light well and the windows. Since it has been brightened up with aluminum paint comparatively little artificial light is required during the day.

EDITOR'S NOTE: Acknowledgment is made to the following manufacturers of painting equipment for information and illustrations: Binks Spray Equipment Co., Chicago, Ill.; The DeVilbiss Co., Toledo, Ohio; W. N. Matthews Corp., St. Louis, Mo.; Paasche Air Brush Co., Chicago, Ill.; The Peerless Pneumatic Systems, Chicago, Ill.; and The Vortex Mfg. Co., Cleveland, Ohio.

Here is another interior view of the plant shown in the headpiece on page 78.

This plant was finished inside with aluminum paint, as described in the text. Note the open construction and amount of steel work to be painted.



Storage Battery Trucks

(Continued from page 65)

So that the men will know about it practically as soon as any parts begin to show signs of wear, a monthly inspection is made of each truck at which time it is also oiled and greased. Each day one truck or tractor is taken out of service and all wearing parts given a complete inspection before they are again lubricated. It takes about a month to go over all the fleet. The gear or worm-drive cases are drained and the inspection plate removed. If the gear teeth show wear, the cause is found and removed. The case is then filled with lubricant and the cover replaced. The differential is oiled, but not opened up and inspected, each month. The driving coupling is also inspected, because if it loosens up it soon destroys the key. The bearing retainers are also examined by removing the hub plates and tightened, if necessary.

Most of the bearings have Alemite fittings and are grease lubricated with a pressure gun. In addition, the steering handle and mechanism are tightened or adjusted, the automatic disconnect tested out and inspected, loose bolts and nuts tightened, tires inspected, and both the operating and emergency brakes inspected, tested and carefully adjusted.

Once a year, however, each truck is taken apart, the grease chambers and feed lines cleaned out, all parts carefully checked for wear, and renewed or tightened up where necessary. After this overhauling, the truck is re-assembled, oiled and greased, and is operating again practically as good as a new truck. Except for the daily and monthly inspections and the annual overhauling, the trucks are seldom out of service or in the shop.

The management most heartily recommends its practice of regular inspection and lubrication of these trucks and tractors. Just how much it saves is, of course, not known with certainty, and can be only roughly estimated. However, it is definitely known that practically continuous service is obtained from the equipment, and that cost of inspection, together with the necessary adjustments and the few repairs, are also low. It always costs less to make a minor repair than it does to make a big one.

IN THIS ISSUE

You May Find the Solution of Your Problems

worked out in the recorded experiences of other operating men

I HAPPEN to know that the Editors of INDUSTRIAL ENGINEER have spent a lot of time on this issue in order to present to plant operators the most effective and least expensive methods to use in connection with maintenance and replacement of plant equipment. After it has been carefully read I recommend that it be put aside where it will be available for handy reference throughout the year. You are certain to run into some or all of the problems discussed, and you will save much time and money by reading the experiences of others and finding out how they solved these problems.

TO PUT it another way, it pays to avail yourself of the experience of others, and INDUSTRIAL ENGINEER endeavors to present the solution of operating problems in such a way and in such variety that its readers can save money.

IN EVERY plant the number of motors is increasing year after year, and with the increase in number come new installations and new processes that must be studied from the standpoint of continuous motor service with as few rewindings and repairs as possible. In this connection I had an experience only the other day that shows the value of drawing on the experience of others, instead of floundering around with experiments that are costly and may or may not lead somewhere.

I WAS called into a large smelting plant to recommend a varnish insulation for motors used in connection with a new process that was truly a motor-killer. It involved zinc chloride fumes and a deposit that required rubber gloves to prevent nasty sores on the hands when inspecting the motors. These fumes and the deposit just raised hob with the ideas of an experienced motor man regarding insulating varnish, and he needed help and asked for it.

WHENEVER you have any puzzling questions on the operation or repair of the equipment in your charge and want information, let us know. We will be glad to offer suggestions, tell you how and where to obtain the information you need, and secure from other plant operators the details of the methods they are using. This is one way to get results quickly, at the least expense in time and trouble to you.

BETWEEN us we made a thorough study of the situation and gathered all the necessary data. Then we wrote a letter to a well-known varnish manufacturer and back came a sample gallon of varnish with full instructions on how to use it. To him the problem was not new and he knew exactly how to go about the necessary correction. These instructions are now being followed and in a few months, after more experience with the situation, I feel certain that we shall have some interesting details about this job for publication.

THE point is that there is a way to get out of almost every difficulty, and the quickest way is to search out the source of information on the subject. Too often we have a tendency to continue doing things as best we can, hoping that a time will come for a complete investigation. That time seldom comes to a busy operator until a serious operating condition faces him, and then to drop everything else is the most expensive method to follow. Troubles are cured quickest and at lowest cost when they are small, and here is where you will find articles such as appear in this and every issue of the greatest value to you.

WHEN you are in trouble, you will always find the Editors of this publication and my humble self lined up on your side. We try to keep you out of trouble through the program of articles prepared for publication, but if you do get into trouble, we are always ready to get under and help you pull out without ever saying, "I told you so" or asking you why you have not read your copy of INDUSTRIAL ENGINEER more thoroughly. In fact, we welcome the opportunity to get acquainted with you, learn your problems, and find out the kind of information that you may need from time to time.

Practical Pete

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Editor*

The Purpose of This Issue

ONE of the real dangers that confront all of us is that we will allow satisfaction with present accomplishments or conditions to blind us to the ever-present opportunities for improvement. Even the ultimate in perfection today will be surpassed tomorrow.

For this reason it is necessary to check up our ideas and practices frequently, both by comparing them with the ideas and practices of other men, and by examining them critically from the background of our own experience. The purpose of this issue is to stimulate the thinking of industrial operating executives on two of their most important problems—careful and efficient maintenance of equipment so long as this is profitable, and prompt replacement when conditions make this advisable.

The methods and viewpoints outlined in this issue represent the thinking and planning of many men with years of practical experience behind them, and are worthy of careful study. Although all of the minor details of any method or system of procedure may not be applicable to every plant, general principles whose worth has been demonstrated in actual practice can profitably be applied under almost any conditions.

It is hoped and believed that this issue will throw additional light on the important problems discussed, and will point the way to their successful solution.

Give Insulating Varnish a Chance

IT IS rather difficult to find a definite agreement among repairmen on the application of insulating varnish to motor windings. Years of experience have taught certain lessons, and current practice in any one shop seems to be based on the experience of the oldest member therein. The use of air-drying varnishes applied by dipping, pouring or brushing will be more or less successful where insulated coils are purchased and a finish coat is used to provide oil-proofness. In some shops where air-drying varnish is mostly used, motors that are known to be subjected to extreme conditions of service will receive treatment with a baking varnish and be baked for a varying period, depending upon the varnish used.

In industrial repair shops, and also in commercial repair shops where a wide variety of rewinding is handled, it has been proved beyond question that the application by dipping of a varnish with good penetrating, covering and cementing qualities, and then baking in a good oven for a definite time to remove the varnish solvent, is the safest and cheapest method to use when vacuum impregnation cannot be employed. The dipping method insures that all crevices in the winding slots will be filled.

When air-drying varnish is employed, it is usually purchased in gallon quantities. On this basis 55 1-gal. cans of a good grade of varnish will cost around $120. If baking varnish is purchased in 55-gal. drums, the cost should be about $80, so that there is a material saving on the basis of the quantity purchased at one time that can be applied towards the necessary dipping tank and baking oven required for a baking job.

This is one good reason for doing away with the brushing and pouring method of applying air-drying varnish, except perhaps on certain emergency jobs. The other reason is that you can not afford to do anything but the best job possible when rewinding a motor.

Proper Attention to Bearings May Prevent a Fire in Your Plant

EVERY operating engineer is, unfortunately, only too familiar with the trouble and expense that may be caused by a hot bearing, particularly if it is located on an important piece of equipment. However, it may not be so well known that hot bearings occupy a very unenviable position from the standpoint of fire hazard, as Edward N. Harriman points out in the October *Quarterly of the National Fire Protection Association.* In this article the statement is made that hot bearings are probably responsible for the major part of the losses, averaging around $8,000,000 annually, classified by the Actuarial Bureau of the National Board of Fire Underwriters as "Friction sparks caused by machinery."

The N.F.P.A. Department of Fire Record has since March, 1925, been keeping a record of fires caused by hot bearings. Up to September of last year, 63 such fires have been reported, including a few important fires prior to 1925. The greater number occurred, as would be expected, in occupancies where combustible dust or flyings were present. Thus, of the 63 fires reported, 28 occurred in cotton mills and other textile occupancies, 9 in paper mills, and 8 in woodworking establishments.

Where fires did not start and spread in combustible dust or flyings, oil-soaked wood or dirt in the vicinity of the bearings was frequently to blame. Careful attention to bearings, and mounting them on incombustible bases, should eliminate a large part of this hazard.

It is obvious that practically all of these fires were the result of neglect. Usually the original reports do not give the exact reason for the heating of the bearings, but occasionally cite specific failure to lubricate them. Similarly, in only a few instances do the reports indicate the exact type of bearing responsible for the fire. In the absence of a specific description, it is probably safe to assume that in most cases they were the plain type, rather than ball or roller bearings.

To say that neglect is the cause of most of the trouble

with sleeve bearings does not solve the problem. So long as oiling and care of bearings are turned over to an unskilled and sometimes more or less irresponsible laborer, as is frequently done, trouble will be encountered.

Most of the trouble with plain bearings can be prevented by putting them under the care of a conscientious workman who has some real knowledge of bearing construction, providing him with suitable lubricants, and exercising sufficient supervision to make sure that the schedules laid down are strictly adhered to.

How Much of Your Equipment Is Drawing a Pension?

HUMANITARIAN considerations may make it highly commendable to give an old and faithful employee an easy job and retain him on the payroll long after his services have ceased to be really valuable. Such considerations do not, however, apply in the slightest degree to plant equipment. This is, or should be, purchased and operated strictly on the basis of its value as an investment, and when for any reason it ceases to pay a satisfactory return it should be discarded at the first opportunity.

One may feel a justifiable pride in pointing to some old machine or device that has been in service for many years and is still in good condition. However, unless it can be shown that that machine is reasonably comparable in efficiency with modern designs, its place is on the junkpile or in a museum—anywhere, in fact, except out in the shop.

In an article on page 51 of this issue, a large number of plant operators and manufacturers discuss the question of replacing obsolete equipment from the standpoint of the yardstick that can be used in determining the real worth of old apparatus, and the conditions under which replacement can be justified.

Study of your equipment in the light of the facts and viewpoints expressed in this article may show how you can most effectively solve the problem of reducing maintenance costs and increasing production.

The Best Safeguard for All Hazards

EVEN with the best safety devices on electrical equipment and circuits, many points cannot be guarded so that they are absolutely fool-proof. Men working around such equipment must exercise care and intelligence, even to a greater extent, perhaps, than in connection with most other industrial equipment or devices. If proper precautions are taken, and practically every experienced man should know them, electrical circuits, even with the highest voltages commonly used around industrial plants, should not offer an especially serious hazard. If the ordinary precautions are ignored, however, the result may be a serious or fatal accident.

New, inexperienced men are not the only ones guilty of neglect or carelessness. For example, an electrician in a mid-Western city was killed when he put his finger into a 2,300-volt pothead to see if the circuit was alive. It was. This man had worked five years for the company and was thoroughly familiar with all necessary precautions that should have been taken.

It is almost impossible to safeguard 100 per cent against accidents such as this. For these and many other hazards the best means of prevention is a careful man. Those supervising others engaged in electrical work should keep continual watch over their subordinates to see that unsafe practices are not followed and that precautions for personal safety are not disregarded. Also, the men with whom "familiarity has bred contempt" require as much watching as the men who are so inexperienced as to be afraid.

Look Outside Your Industry for Ideas

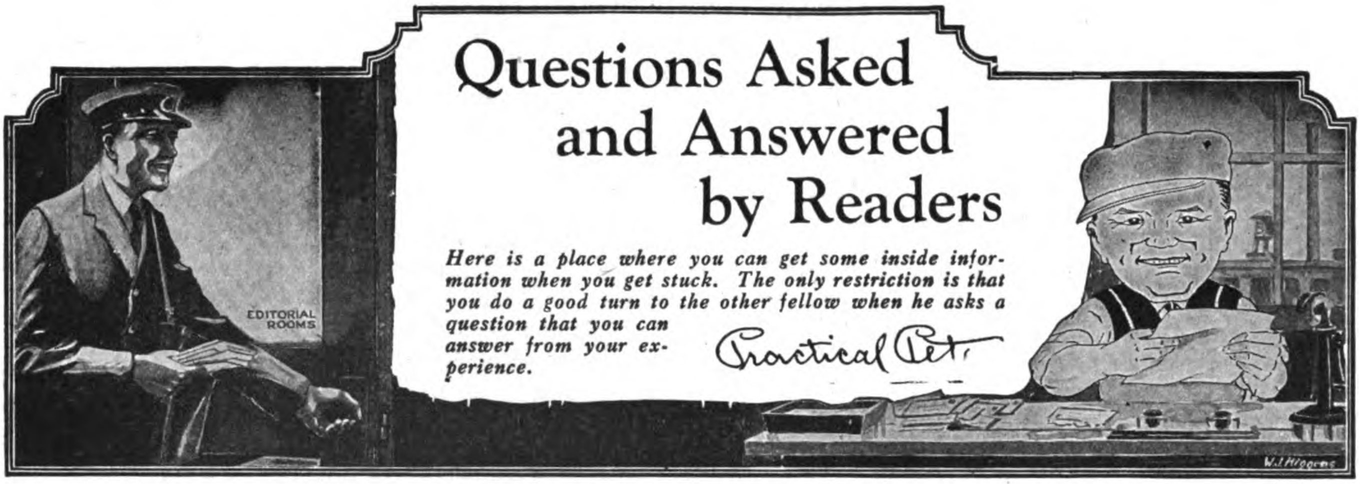
EVERY operating executive should feel proud, and justly so, when he has developed original ideas and applied them to his own industrial problem. The opportunities for entirely new ideas, however, are fewer than are the occasions for adapting those common in other industries to meet the requirements of the problems he is facing.

Strictly original ideas usually require research, for which operating men seldom have the time or facilities. Every industry, however, can adapt many of the methods and practices in vogue in other industries. These may be obtained from plant visits or through the descriptive articles appearing in publications such as INDUSTRIAL ENGINEER.

Lack of the broad-visioned ability to analyze and discover the basic principles in operating plans is one of the common shortcomings of operating and also many other executives. Men with this ability, if they have any executive talent, are practically sure of advancement to positions where they can devote more time to mental effort, which practically always obtains greater reward for both the company and the men than does mere hand work.

As an example of this, the inspection record which is the basis of a very successful method of handling maintenance work was adapted from the air brake inspection system used on railroads. To many, freight cars and woodworking machinery would seem to have no relationship, but the inspection plan for one, with the necessary modifications, is working very well with the other.

Incidentally, the mechanical superintendent who worked up this idea has so proved his ability with this and many other suggestions that today he is the manager of another nationally known company. Men of balanced ability, particularly those who have a broad enough viewpoint to work out and apply ideas, have their talents recognized and rewarded, either inside or outside of their organization.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer This

Characteristics of Fynn-Weichsel Motor.—I shall appreciate it if some reader will explain in non-technical terms the characteristics, construction, and principles on which the Fynn-Weichsel motor operates. Is it necessary to use special control equipment with this motor?
Lansdale, Pa. H. T.

* * * *

What Is Best Kind of Insulation For Semi-Closed Slot Motors?—I shall appreciate it very much if readers will tell me whether it is better practice to use varnished cambric between each coil in a semi-closed slot motor, thereby insulating each coil from its neighbor, or to tape each coil separately and then use insulation only between phases.
Rome, Ga. M. S. C.

* * * *

Substitute for Shearing Pins.—We have a conveyor line which is driven by a 3-hp. motor through a worm reduction gear. A coupling with a shearing pin is placed between the conveyor and reduction gear for protection when the conveyor becomes clogged, which it frequently does. Some time is required to replace the shearing pin and I wish to eliminate it if I can. Could a clutch be used that would slip and thus absorb the shock when an excessive load comes on, as is the case when the conveyor becomes blocked.
Youngstown, Ohio. J. L. B.

* * * *

Advantages of Three-Phase, Four-Wire System.—As there seems to be an increasing use of three-phase, four-wire systems, I shall appreciate it if some reader will answer the following questions: What are the principal advantages of a three-phase, four-wire system over a three-phase, three-wire system? Are there any special conditions under which these four-wire systems should or should not be used? Can three-phase, three-wire, watt-hour meters be used to measure the current consumption in three-phase, four-wire systems?
Pittsburgh, Pa. R. L. P.

* * * *

Changing Speed of Electric Drill.—I have an electric drill that I wish to use for other purposes which will require a lower speed. The nameplate is missing, but the present no-load speed is about 1,800 r.p.m. and the full-load speed 1,200 r.p.m. The drill is driven by a universal motor and is capable of boring a ½-in. hole in steel when operating from a 110-volt, a.c. circuit. Will some reader please tell me how I can reduce the motor speed to one-half or three-quarters of its present value? What is the principle involved in increasing or decreasing the speed of a universal motor?
Moline, Ill. J. M. M.

* * * *

Operating Generators in Parallel—We have a 400-kw., three-wire, 110/220-volt, compound-wound General Electric generator which I wish to operate in parallel with a 100-kw., two-wire, 220-volt Crocker-Wheeler generator. Can these two machines be satisfactorily operated in parallel while the 400-kw., three-wire machine is supplying a three-wire, 110/220-volt load? I wish to obtain both 110 and 220 volts from the 400-kw. machine and at the same time increase our 220-volt generating capacity by paralleling the two-wire, 220-volt, 100-kw. machine with it. If these machines can not be operated as described, please give me the reason. If they can be so operated what scheme of connections must be used, and what precautions observed in paralleling them? Any information that readers can give me will be greatly appreciated. J.F.
Dansville, N. Y.

* * * *

Answers Received To Questions Asked

Using Large Diameter Pulley on Motor.—Is it practicable to use a 20-in. pulley on a 25-hp., 750-r.p.m. motor? This would result in a peripheral speed of the pulley of 3,926 ft. per min. Would this be good practice? What objections would there be to using this size of pulley on the above motor in view of the fact that the motor manufacturer does not recommend a pulley of this diameter? Can some reader tell me what types of pulleys I could use or could not use in this case?
Toledo, Ohio. F. H.

I believe that F. H. will find the use of a 20-in. diameter pulley on a 25-hp., 750-r.p.m. motor to be sound engineering practice. We have repeatedly made similar installations which have worked perfectly, up to a 36-in. pulley on a 150-hp., 450-r.p.m. motor. In fact, for a short-center drive, a slow-speed motor with a large driving pulley will work much better and sometimes save using an idler.

I believe that the main objection of the manufacturers, and the reason they do not recommend large pulleys, is based on cost considerations. Motor prices run roughly by frame sizes; the same frame size of motor will develop approximately twice the power at twice the speed, so that even down to the cost of the pulley, it is economy to use as high a motor speed and as small a pulley as the speed and pulley diameter of the driven shaft will allow.

The belt thickness must always be taken into account, because if the diameter of the pulley is too small the continual bending of a thick belt over it will shorten its life. Another advantage of high-speed induction motors is that they have slightly better efficiency and power factor than the slower-speed motors. However, where I have a slow-speed motor available I believe that it is better to use the proper size of pulley rather than buy a new motor or trade with a used machinery dealer for a higher-speed motor, the history of which I know nothing.

Any sort of pulley can be used as long as it is well balanced. However, I have found that wooden pulleys are affected by atmospheric changes and are hard to keep tight on heavy service. Most pressed-steel pulleys are a little light for the belt pulls usually encountered on motor drives and unless especially constructed and balanced for high speed the circumference is just enough off the true circle to receive an alternation of stress and a kneading action that eventually loosens up the joints. It must be remembered in both these cases that these types of pulleys are not designed or recommended for this kind of service by the manufacturer.

The standard so-called paper motor pulley operates very well with endless belts or Clipper and similar lacing, but will eventually lose its crown if the belt is allowed to slip much. Paper pulleys are also cut out quickly by certain types of belt hooks, and the use of these in motor belts on paper pulleys should be permitted only as an emergency measure.

This leaves only the cast-iron pulley, and for a large diameter motor pulley the writer would prefer a good, solid cast-iron pulley, turned and balanced for the speed at which it is to run. In cases where these pulleys must be made up locally in emergency I have found that using a pattern with a solid web and finishing the pulley all over will give a pulley that will be sufficiently accurately balanced, without special treatment. H. D. FISHER.
Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

* * * *

In figuring a belt drive such as F. H. has in mind, it is important that the maximum speed of the belt must never exceed 5,000 f.p.m. Above this speed the centrifugal force reduces the adhesion and consequently the belt pull. [EDITOR'S NOTE: Recent experiments indicate that higher speeds may be used.] Therefore, the pulley diameter

on a 1,725-r.p.m. motor should never exceed 11 in., 16 in. on a 1,140-r.p.m. motor, and 25 in. on a 750-r.p.m. motor. The frame diameter of a 25-hp., 750-r.p.m. motor rarely exceeds 35 in. Motors of this rating are usually equipped with pulleys about 12 in. in diameter with a 12-in. face which is intended for an 11-in. belt. These are the proportions which give a conventional and well-proportioned appearance.

Motor manufacturers do not recommend the use of oversize pulleys because of the possibility of extra bearing trouble, belt slippage, increased likelihood of overloading, and unsymmetrical appearance. However, there are many successful installations of motors of comparatively small horsepower with oversized pulleys for short belt drives where the high speed of the driven pulley is essential and it is not desired to use countershafts.

It is both possible and practicable to use a pulley 20 in. in diameter on a 25-hp., 750-r.p.m. motor providing the pulley is accurately balanced and the motor bearings are rugged enough to carry the extra weight of the oversize pulley and belt.

A well-made cast- or pressed-metal pulley or a wooden or fiber pulley should give complete satisfaction, providing there are no unusual local conditions to contend with, such as excessive dust, moisture or acid fumes at the place of installation.

East Kingston, N. H. H. S. RAMSAY.

* * * *

The following experience in the use of a large diameter pulley on a motor will probably be of assistance to F. H. Some time ago when testing ball bearings for endurance we ran them continuously at high speed under heavy load until they broke down. Sometimes this necessitated operating for weeks at a time without stopping.

This job required a 50-hp. motor, but there were available only two 25-hp., 750-r.p.m., squirrel-cage motors, which we ran in multiple. To obtain the desired speed on the bearings undergoing test it was necessary to equip these motors with 24-in. pulleys for 8-in. belts. This gave a peripheral speed of 4,712.4 f.p.m., which is higher than F. H. intends to use. The pulleys which we used had cast-iron hubs and spokes with wooden rims. This test extended over a period of 8 mo. and no trouble was experienced with the motors or pulleys.

Using a large diameter pulley on a motor is not good practice, but F. H. should not experience any difficulty, if our tests are to be taken as a criterion.

Chief Electrician, W. J. LEES.
Savage Arms Corp.,
Utica, N. Y.

* * * *

Operation of Electric Refrigerator—Would there be any objection to using brass valves, pipes and fittings, instead of copper, between the compressor and cooling coils of a small electric refrigerator, similar to a household unit, that uses sulphur dioxide as the refrigerating medium? What material is best suited for use as packing and gaskets? What kind of lubricating oil is best adapted for the compressor? What pressures should be carried on the intake and on the discharge when the compressor is running, and when it is not running? What is the best method of charging a unit of this size? I shall be very grateful for any information that readers can give me on these questions.

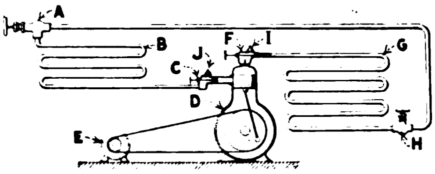
Oak, Neb. H. L. M.

In reply to H.L.M., brass pipes, valves and fittings may be and are used; in fact, iron pipe and fittings could be used. The things to guard against are moisture and foreign particles on the inside, and a multiplicity of joints. Copper tubing is usually used, most manufacturers furnishing a specially dried, annealed and tested tubing. Belled, automobile-type fittings are used for unions and at the pipe ends.

Thin asbestos composition or paper gaskets are used. I have employed blotting paper successfully in an emergency. Packings, when used, are usually of the metallic coil type.

Moisture-free mineral oil, exactly similar to the familiar "American Oil" used internally, is the best, but boil it before using.

The intake and discharge pressures



General arrangement of a refrigerating machine that utilies sulphur dioxide gas.

The expansion valve is shown at *A*, *B* is the expansion coil. The suction shut-off valve is located at *C*, *D* is the compressor which is operated by motor *E*, *F* being the discharge shut-off valve. The condenser coil and shut-off valve are located at *G* and *H* respectively. *I* is the plug in valve *F*, and *J* is the plug in valve *C*.

vary a great deal with the type of condenser, expansion valve or float valve, and expansion coil; in other words, with the type of expansion system used. With Kelvinator outfits the pressures vary, with the size, from 1 in. vacuum to 3 lb. pressure on the low side when running, and from 50 lb. up, on the high side. The high side or discharge pressure varies with the room temperature around the condenser coil. When the machine is not running the pressures tend to equalize, depending on the condition of the compressor valves and expansion valve.

To charge a unit of this type, it is necessary to go through several operations, and the exact way the "charge" is placed in the unit will vary a great deal with the layout of the various parts of the system. With the Kelvinator outfit a vacuum can be drawn on the system after removing plug *I*, part of valve *F*, as a means of expelling the air in the system, and after the system is shut off at *F*. A gage is installed in the plug opening *J* in the suction shut-off valve *C*. When as complete a vacuum as possible is obtained, the plug hole at *I* is filled with compressor oil. If the oil does not sink in or bubble, the system is considered to be tight.

The next step is to connect a drum of sulphur dioxide, equipped with proper fittings and valve. A blow torch will also be required. The drum is screwed (loosely at first) into the highest point in the unit. The plug at *I* and the drum valve are opened slightly for a moment in order to allow the gas to displace the air in the passage between the drum and the valve *F*. Tighten the connection between the drum and the valve. The valve *F* is adjusted so as to open the passage between the drum and the condenser coil *G*, and then the drum valve is opened, the liquid sulphur dioxide now being able to flow into the condenser coil. Heat the bottom of the drum with the torch; close the valve *F* so as to shut off the plug *I* from the drum; remove the drum, and the charging is complete. With other machines the filling operation may be different, although the general principle is essentially the same.

The essential point to remember when working with sulphur dioxide is that when it is mixed with water (or moisture from the air) sulphurous acid is formed, which will at once corrode the pistons and cylinder walls and may cause the pistons to seize; so every precaution must be taken to keep air or moisture out of the system.

Manchester, N. Y. GARSON A. REESE.

* * * *

In reply to H.L.M.'s questions, I know of no reason why brass cannot be used instead of copper for the connections between the compressor and cooling unit. Brass is successfully used for this purpose in several of the machines now on the market. Dry sulphur dioxide has very little chemical action on metals.

For gaskets at the header on the cooling coil use lead; at various other places on the compressor, paper gaskets, well shellacked, may be used. For packing valves use single-strand Mogul. Use new packing whenever the stems are removed for any reason.

Ordinary oils should not be used in a machine employing sulphur dioxide as the refrigerant. The oil to be used must be one which has undergone a special refining process. This oil is readily obtainable from any of the manufacturers of electric refrigerators using sulphur dioxide as a refrigerant.

On the intake or high-pressure side, the working pressures are from 50 to 60 lb. per sq.in. The pressure on the discharge or low-pressure side is atmospheric or zero gage pressure.

If the machine is to have its initial charge, it is best to first draw a vacuum. First, the compressor should be baked in an oven at a temperature of about 200 deg. F. for about 1 hr.

Next make a three-way connection at the head of the compressor. One line should go to the charging valve on the compressor, one to the SO_2 (sulphur dioxide) container, and the third to the vacuum pump.

Draw a vacuum of about 28.5 in. for 20 min. After the vacuum has been drawn, close the valve connecting with the vacuum pump, and open the valve at the SO_2 container.

Place hot towels around the container so that the heat will drive the gas out of the container and into the compressor. In order to check the amount of SO_2 that is going into the compressor, place the container on

scales and note the weight. Care should be taken not to apply too much heat to the container, as they are generally provided with safety plugs which fuse at about 160 deg. F.

ARCHIE L. FORGER.

Chief Electrician,
G. A. Head Electric Co.,
Laconia, N. H.

* * * *

Grouping of Wires in Conduit for Two-Phase System—I have installed some 3-in. conduit runs, to be used for two-phase power supply circuits. These conduit runs are about 25 ft. long. In them I wish to place 500,000-circ.mil cables and since it is possible to get only three cables of such size in a 3-in. conduit, it will be necessary to group the cables in two conduits. Will it be satisfactory to place the two A-phase cables in one conduit and the two B-phase cables in the other? In a three-phase system, this should not be done; hence, I am doubtful about doing it with two-phase cables. Would it be preferable to place one A-phase cable and one B-phase cable in each conduit? If so, which of the two B-phase cables should be placed in one conduit with the first A-phase cable? Please give me some information on these points.

St. Lambert, Quebec, Can. J. M.

Answering J.M., in alternating-current systems all the wires of a circuit must be drawn in the same conduit. A four-wire, two-phase system should be treated as two single-phase circuits, each circuit carrying one-half of the power at the same voltage.

Therefore, it will be satisfactory to place the two 500,000-circ.mil cables for phase A in one 3-in. conduit, and the two 500,000-circ.mil cables for phase B in another 3-in. conduit.

H. S. RAMSAY.

E. Kingston, N. H.

* * * *

It is safe for J. M. to group the wires in conduit for his two-phase system, for it is regular practice with a two-phase system to put two conductors of the same phase in one conduit; that is, the two conductors of the A phase in one conduit, and the two conductors of the B phase in another conduit.

It would not be safe to put one A-phase conductor and one B-phase conductor in one conduit, and the other A- and B-phase conductors in the other conduit. The reason for this is that the magnetic fields of the two A conductors in one conduit neutralize each other, with the result that the effect on the conduit is negligible.

This may be explained as follows: Let us call one wire of the A phase the going wire and the other the return wire. Then, if at any instant the magnetic flux around the going wire is in a clockwise direction, the flux around the return wire will be in a counter-clockwise direction because the same current is flowing in the opposite direction. Therefore the field of one wire neutralizes that of the other.

The foregoing is not true for a three-phase circuit, as the magnetic fields set up by two conductors in one conduit would not neutralize each other, and the resultant magnetic effect, since the currents in the two conductors are 120 deg. out of phase, would be impressed on the iron conduit, and thus cause heating, even in as short a run as 25 ft. The A-phase and B-phase conductors placed in one conduit would have a similar effect, since the currents differ 90 deg. in phase.

With currents of very low value the heating might not be serious, although there would be an added voltage drop in the conduit run due to the so-called inductive effect.

It is assumed in this case that the currents are on the order of several hundred amperes. With currents of such magnitude, serious heating would undoubtedly result if the conductors are improperly grouped in the conduit.

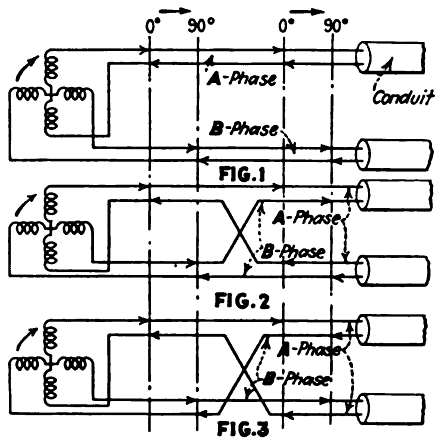
C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

* * * *

Answering J.M.'s question, it will be satisfactory to put the two A-phase cables in one conduit and the two B-phase cables in the other, as illustrated in Fig. 1 of the accompanying illustration, because a two-phase, four-wire system may be regarded as two separate single-phase circuits which have a difference in phase of 90 deg.

Should one A-phase cable be placed



These diagrams indicate the correct and incorrect methods of grouping conductors of a two-phase, four-wire system in two conduits.

Fig. 1 shows the correct method. Figs. 2 and 3 show an incorrect method, but the heating of the conduits in Fig. 2 would be more than in Fig. 3. Arrows indicate the instantaneous direction of current in the different wires.

along with either of the B-phase cables in a conduit, heating of the conduit would result. If the two cables (one A-phase and one B-phase) were placed in one conduit so that the instantaneous direction of the current in each cable was the same, but differing in phase by 90 deg., as shown in Fig. 2, the heating of the conduits would be more pronounced than if the two cables were grouped so that the instantaneous direction of currents in each cable was opposite and differing in phase by 90 deg., as in Fig. 3.

With two-phase, three-wire systems and three-phase, three wire systems the three wires should be always run in the same conduit. ERNEST DICKINSON.

Kimberley, B. C., Can.

* * * *

In answer to the question by J. M., his suggestion to place two A-phase cables in one conduit and the two B-phase cables in the other conduit would work out satisfactorily.

If J. M. should undertake to operate them according to his second suggestion, placing one A-phase and one B-phase cable in each conduit, he would experience trouble in the way of low voltage, and the conduit would heat due to the transformer effect of the layout. A. C. BARKER.

Chief Electrician,
W. S. Libbey Co.,
Lewiston, Me.

* * * *

J. M. can use the same reasoning with a two-phase circuit as with a three-phase. A single conductor carrying an alternating current should not pass through a tube or other closed circuit of magnetic or conducting material. When such is the case, even with a steel pipe a few feet long, there is induced in the pipe or conduit a current which results in a definite loss of power.

The cable will carry direct current economically, as these losses continue for only a very short time while the circuit is being closed or opened. While the current is increasing or decreasing the magnetic flux surrounding the cable is expanding or contracting; that is, it is cutting through the surrounding material.

The action on a closed metallic circuit linked with this moving flux is the same as that in the secondary of a static transformer: A current is induced in the closed metallic circuit and, if the closed metallic circuit happens to be composed of iron or steel, the circuit is also magnetized and much energy is lost in reversing the magnetism with each cycle.

Looking in the direction of the flow of current in a cable, magnetic whirls are set up around it in a clockwise direction. If another cable is laid beside the first, but carrying a current toward the observer, this cable will tend to have a surrounding counter-clockwise flux; the resultant magnetism in a pipe surrounding the two cables will be very small, as the flux from one cable tends to neutralize that of the other, as they are moving in opposite directions.

With alternating current, at any given instant the resultant of the flux from the two conductors of one phase of the two-phase, four-wire system will be very small (theoretically zero), and that from three phase with the three conductors in one pipe will also be negligible.

In both cases the currents are moving in opposite directions and, therefore, the magnetism which links the conductors with the "secondary circuit" (pipe, and the like) is only that due to some unbalanced condition of the load, generating equipment or conductors. With two wires of a three-phase system in one pipe, this unbalanced condition is very serious and loss will result from hysteresis and eddy currents to such an extent as to make the installation unsatisfactory.

Therefore, the two A-phase conductors may be placed in one conduit and the two B-phase conductors in the other, for in this way the magnetic field of the conductors will neutralize each other. However, should one A-phase and one B-phase conductor be placed in the same conduit, twice as much heating of the conduit will be obtained as would be the case if only one

conductor were in a conduit. This is because the B-phase current lags 90 deg. behind the A-phase current; hence one current starts when the other ends and at no time do they oppose each other. D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

Regarding J.M.'s question, it will be best to run the two A-phase cables in one conduit and the two B-phase cables in the other. By so grouping the cables, the magnetic flux around one cable is neutralized by that of the other cable in the same conduit, thus eliminating a large part of the induced currents and consequent heating.
Murphy, Idaho. ALEX BRENNER, JR.

* * * *

Use of Time Switches.—Many times I have felt that clock-operated time switches could be used to advantage in my plant, for instance on baking ovens and yard lights. Before installing these devices, however, I should like to obtain the viewpoint and experience of readers as to where these switches can be used to advantage around the industrial plant. Where are readers now using these switches to advantage and, also, where do they think they could use them if they were to install them at every point at which they would be of value?
Pittsburgh, Pa. K. E.

There seems to be some question in K.E.'s mind as to the reliability of time switches. Several years' experience with time switches of various sizes and makes under severe service and climatic conditions has convinced me of their dependability for a variety of purposes.

I have used clock-operated time switches here in Porto Rico mainly for two purposes. The first of these is for switching two wattmeters in and out of circuit, at definite, fixed hours, in connection with a two-rate service. This calls for a high degree of accuracy and reliability. We have between 30 and 40 time switches installed for this purpose, and have found them entirely satisfactory.

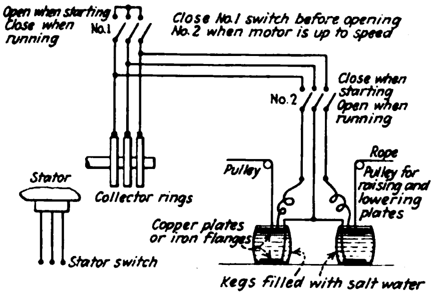
The second use to which we put them is for switching sign lighting on and off. Many of the time switches in this service are installed out of doors with consequent exposure to dampness and weathering incident to such location. In this service they eliminate the necessity of two visits each evening to the sign location to turn the lights on and off—a single visit once a week to wind the clock and check its setting now suffices. For severe service such as this, clocks have been developed with practically all parts, except the case, made of brass to prevent rusting. As a further protection, the case is waterproofed.

To insure reliable service from time switches it is necessary that the switch size be adequate for the current that is to be carried and interrupted.

The reliability of time switches is evidenced by the fact that they have been used to control the operation of many small, automatic hydro-electric plants where their failure to function properly would be a serious matter in most cases. FREDERICK KRUG.
Asst. to President,
Porto Rico Railway, Light & Power Co.
San Juan, Porto Rico.

Can Slip-Ring Motors Be Started by a Compensator?—I have several three-phase, 440-volt, wound-rotor, induction motors ranging in size from 25 to 150 hp. I have several spare compensators which I would like to use for emergency starting of these motors in case anything goes wrong with the present drum controller and secondary-resistance type of control. My plan is to short the slip-rings and start the motors with a compensator just as though they were squirrel-cage induction motors. Is this practicable? Is there any danger of damaging the motors? I would like to know the experience of other readers in this regard.
Chicago, Ill. W. J. A.

Referring to W.J.A.'s question, a wound-rotor motor may be started by a compensator after short-circuiting the rotor windings or the brush rigging at the collector rings. This method of starting will have no ill effects on the motor, providing it starts under a light load. If, however, the motor is loaded, the starting current in the stator will be several



This shows how a water rheostat can be arranged to start a wound-rotor, induction motor.

times normal, and excessive internal stresses may injure the windings.

A method that can be used to advantage for emergency starting is to employ the same switch for impressing the voltage on the stator, but use a water rheostat similar to the one shown in the illustration in place of the defective controller and resistances. Although this is a makeshift arrangement, it will give the motor the same starting and operating characteristics as before. H. E. STAFFORD.
Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

* * * *

In reply to the question asked by W.J.A., I would say his plan is feasible but it has certain limitations; otherwise there would be no need for wound-rotor motors.

If a wound-rotor motor be short-circuited at the rings and the voltage applied to the stator through a compensator, its starting torque will be materially reduced and, if the motor is connected to a load that requires a high starting torque, the motor will fail to start. Should the load, however, be one which is easily started and the greater part of the load applied after the motor reaches full speed and is running on full line voltage, no trouble will be experienced. There is no more danger of damaging the motor by using a compensator than by using the secondary resistance method. The danger is that the motor will fail to start the load, because the necessary resistance method gives a very high starting torque.

In the past few years I have used the compensator method a great many times and the occasions have been rare indeed when it was necessary to raise the taps in the compensator to allow a higher voltage to be impressed on the motor during the starting period. However, on one occasion a few months ago when we tried this method of running a 100-hp., wound-rotor G.E. motor on a drive consisting of two long, heavy lineshafts to be started, we experienced a little trouble but after the compensator voltage was raised by changing to the next higher taps, the load immediately started and the motor ran satisfactorily. This method, if studied carefully, can be used to great advantage.

It happens many times that a squirrel-cage motor burns out and the only available spare is an idle, wound-rotor motor. By using the compensator method, changing of starting apparatus may be avoided and much valuable time saved. In case the loads that W.J.A. has to start do not require a high starting torque, he can easily use his wound-rotor motors with compensators and feel fairly confident that they will start the load. LEE F. DANN.
Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

Regarding the question asked by W.J.A., I would say that it is possible to start a slip-ring motor by means of a compensator, but the design of the slip-ring motor is such that it has a weak starting torque when the rings are short-circuited; so some resistance should be connected across the slip-rings, before current is applied to the stator by means of a compensator, in order to give the rotor a greater starting torque.

With a slip-ring motor, the primary winding is similar to that of a squirrel-cage motor, but there is a difference in the design of the rotor windings. The rotor of a slip-ring motor has a phase-wound winding which consists of insulated conductors, similar in form to its stator winding, whereas with a squirrel-cage motor, low-resistance, short-circuited rotor bars are used. If the rotor of a slip-ring motor happens to be in a certain position with its slip-rings shorted, the rotor may fail to start when current is applied to the stator. However, if some resistance is left across the slip-rings during the starting period, the starting torque of the motor will be increased for a given amount of stator current. When the rotor has nearly attained its running speed, the rings can be short-circuited by a properly arranged switch. This is a poor method for operating a slip-ring motor, but it can be used in an emergency when the regular control equipment is out of commission.
R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

* * * *

Replying to the question asked by W.J.A., it was necessary a few months ago to replace a damaged drum controller that was used on a 100-hp., 440-volt, three-phase, wound-rotor motor.

This controller was damaged beyond repair and as this motor was an important one it was necessary to keep it in operation or shut down the plant. After looking around the shop, a compensator was found which had been used with a 175-hp. motor. This compensator was then connected to the damaged motor, and the three slip-rings on the motor were shorted by soldering a strip of copper across them. This motor is still being operated with the compensator and so far is performing well. WM. MCGUIRE.
Electrical Engineer,
Carbondale Machine Co.,
Carbondale, Pa.

* * * *

The method of operation proposed by W. J. A. is entirely practical. I have started slip-ring motors with squirrel-cage motor starters a number of times, and this method gives satisfaction so far as actual starting is concerned, although it cannot always replace the grid control on variable-speed motors or on motors that must start up gradually, such as hoist or crane motors. In order to start a wound-rotor motor with a compensator the rings or brush rigging must be short-circuited with a conductor of ample current-carrying capacity; otherwise, the power of the motor at full load may be reduced. A simple means of determining whether or not the wire that shorts the slip-rings has sufficient current-carrying capacity while the motor is running under heavy load is to short-circuit the slip-rings with a jumper wire also. If a spark results when the jumper is removed from the rings, this will indicate that the short-circuiting wire is too small. GRADY H. EMERSON.
Birmingham, Ala.

* * * *

In answer to W.J.A., it is practical to short-circuit the secondary leads of a wound-rotor motor and start it with a compensator, since a wound-rotor motor with the rings short-circuited has essentially the same characteristics as a squirrel-cage induction motor.

There are two reasons for the application of wound-rotor induction motors. First, with this type of motor the current drawn from the line in starting will not be more than 150 per cent of full-load current, in order to develop full-load torque. The second reason is that when more than full-load torque is required the wound-rotor motor will develop a maximum torque of approximately 250 per cent of full-load torque in starting, if the proper amount of secondary resistance is used.

A squirrel-cage induction motor started on the 70 per cent voltage tap of the compensator will develop approximately full-load torque in starting, and when full-load voltage is applied it will develop 200 per cent of full-load torque in starting.

A wound-rotor motor, having its secondary rings short-circuited, develops less starting torque for a given applied voltage than a squirrel-cage motor, because the greater self-induction of the wound rotor, the larger air gap and the distribution of the rotor windings, each has its effect in reducing the starting torque.

If the starting torque required is not great, compensator starting will be satisfactory; but when the starting requirements are heavy, full voltage may be required at the start and in this event the brushes may glow and burn during the starting period. When a wound-rotor motor is just about able to start its load, it would be practically impossible for this motor to start the load if the rings were short-circuited and the current applied through a compensator even if full voltage were applied to the primary windings.

When trouble is experienced in the starting of a heavy load by the compensator method, it may still be possible in some cases to start the motor satisfactorily by short-circuiting only two of the secondary leads, leaving the third one disconnected until the motor has partly come up to speed and then this third lead should be short-circuited. This method of starting has the effect of increasing the resistance in the secondary circuit. L. T. JOHNSON.
East Cleveland, Ohio.

* * * *

Changing Speed of Induction Motor.—What will be the horsepower and power factor of a 3-hp., Fairbanks-Morse, 1,200-r.p.m., 6-pole, 54-slot, standard factory wound, 60-cycle, 440-volt induction motor, wound with No. 16 wire in 54 coils with 28 turns per coil, span 1-9, when this winding is regrouped for eight poles instead of six?
Portland, Ore. P. M. W.

Regarding P.M.W.'s question, the method of connecting the coils is not given, but the following explanation will indicate what steps will be necessary to produce a satisfactory winding.

If the winding is to be connected for an 8-pole grouping, with 24 groups consisting of 18 groups of 2 coils each and 6 groups of 3 coils each, using the original connection, the rating would be reduced to about 2 horsepower. As the speed will be reduced from 1,200 to 900 r.p.m., the coil turns should be increased by a ratio equal to 1,200 ÷ 900 and the size of wire should be decreased.

Assuming that the old coils with the same number of turns and size of wire per coil which composed the six-pole windings will be used, regrouped and reconnected by the original type of connection into an eight-pole winding, the line voltage will have to be less, for the new line voltage should be $(900 \div 1{,}200) \times 440 = 330$ volts.

The effect of the coil pitch on the line voltage in this case can be disregarded, for with six poles the 1-and-9 pitch is one slot under full or 100 per cent pitch, as $54 \div 6 = 9$. For eight poles, the full pitch would be 1-and-7¾, as $54 \div 8 = 6\frac{3}{4}$. Then, as a 1-and-9 pitch will be 1¼ slots over pitch, and as over-pitch has the same effect as under-pitch, there will be only a ¼ slot pitch difference between the six- and eight-pole windings, which difference is hardly worth considering.

It is evident from the above information that the coils of this motor cannot be connected in accordance with the original method, regrouped for eight poles, and then be put across a 440-volt line, as this procedure would necessitate operating the motor on 33⅓ per cent overvoltage. A. C. ROE.
Wilkinsburg, Pa.

Cause of Fuses Blowing on Transformers.—During a recent violent lighting storm, the fuses were blown on one of our 10-kva., 2,300/220-volt, single-phase transformers. This transformer supplies a small lighting distribution system. The transformer is protected by a pole-type lightning arrester. After the storm was over the fuses were replaced and the transformer operated satisfactorily. I shall appreciate any information that readers can give me on what caused these fuses to blow. I will be very much indebted to any reader who will advise me on this subject.
Wichita, Kan. Z. F. D.

The incident as outlined by Z. F. D. is not in the least an uncommon occurrence. This assertion will be borne out by the reports of the trouble department of any public utility company having any sort of an extended or extensive electric distribution system, especially after a lightning storm. The cause of the fuses blowing is undoubtedly due to a sudden inrush of current caused by a momentary rise of the voltage at the transformer terminals, which condition is due to the addition of the voltage induced on the line by a nearby lightning or heavy static discharge, to the normal line voltage.

Increase in exciting current in a transformer of modern design, due to an increase in the impressed voltage at the terminals, is in much greater proportion than the actual increase in voltage, depending, of course, upon the design of the transformer. I know of one instance where there was an increase of 100 per cent in the exciting current, while the line voltage increase was only 10 per cent. The voltage rise in question is of such extremely short duration in point of time, being of the order of millionths of a second, that the immediate effect or damage to the transformer may be negligible, particularly if, as in this case, a nearby arrester can discharge and thereby immediately relieve the line of the high potential condition.

If, on the other hand, no arrester or fuse were provided which could take care of such a condition, the voltage to ground would build up at the terminals of the transformer until a flashover occurred to ground, a bushing failed or the winding was punctured. As a rule in a transformer of modern design, the terminal bushings are designed to flash over before the voltage rise is sufficient to puncture them, and the end turns of the transformer nearest the line connection are more heavily reinforced with insulation. Hence, a failure from either of these causes is the least likely with modern apparatus.

The character of a lightning discharge seems to be such that it does not travel far in a highly inductive winding, such as a transformer, and the rise in voltage due to the choking effect of the winding quite commonly causes a flashover at the terminals, should the fuse not blow or partial relief be afforded by the discharge of the arrester. Experience indicates that the arrester should be located as close to the transformer line connection as it is possible to place it, on the same crossarm if possible, to make the reaction caused by the arrester discharge immediately effective to the transformer.

C. OTTO VON DANNENBERG.
Electrical Division,
General Engineering and Management Corp.,
New York, N. Y.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Checking Up and Servicing Electrical Troubles

A SYSTEM of keeping a graphic record of trouble calls throughout our plant is based on making each trouble call count for so many points according to the importance of the operation and the time lost in the delay. The plant is divided into sections as, for instance, the hot mill, the annealing rooms, the tin house, the assorting room, and the like. One electrician is in charge of each department and his sole duty is to go over the electrical apparatus in his division and keep it in first-class condition. Each morning he is given the reports from the trouble shooters for the previous 24 hr. so that he can follow up all jobs.

The "Troublegraph" is plotted on a large sheet, the number of trouble calls received during the past 24 hr. being represented by a red line, which rises and falls in accordance with the amount of trouble. Hence, our slogan is, "Keep the red line down!" Every man in charge of a department has his name and department listed on this sheet and every morning the number of points chargeable to his department are marked up. If there has been no trouble his space is marked "0."

A meeting is held once a month in which every man participates, suggestions being offered by the men for improving operating and safety conditions throughout the plant. The "red line" also comes in for discussion, the men whose departments were responsible for running the red line up being asked to give an explanation and urged to do better in the future. Many things are brought to light in this manner, which otherwise might be missed. Careful inspection is made on all work done by the men, whether it is repair work or new work. Since instituting this system, our service troubles have fallen off one-half or more.

In order to give prompt attention to electrical troubles throughout the plant a 20-station annunciator has been installed in the shop, with push buttons to operate the annunciator located in almost every department of the plant. When a trouble shooter is wanted in any part of the mill, the annunciator indicates the location of the button station and very little time is lost in getting on the job, thereby saving the time and trouble of sending a man to the shop every time an electrician is wanted. The trouble shooter can also answer the call by pressing a button in the shop which lights a lamp at the button station, signifying that the ring has been heard.

We are planning to install red signal lights on the top of the main drive gears of each of the six 1,000-hp. drive motors with which the hot mill of the tin mill is equipped. There will be two whistles placed at these motors so spaced that either whistle can be heard in any part of the mill. This system is to be used in calling the proper attendant to any motor that needs attention.

C. H. SMITH.

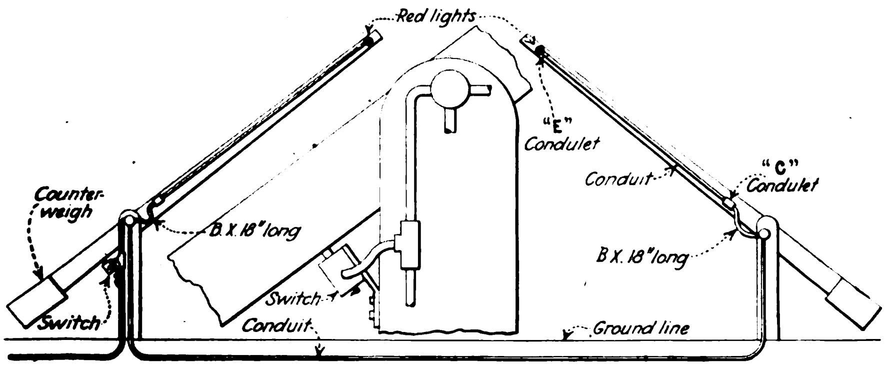
Chief Electrician,
Sheet & Tin Plate Division,
Bethlehem Steel Co.,
Sparrows Point, Md.

Controlling Warning Lights on Crossing Gates

RECENTLY a pair of gates guarding a railroad crossing were fitted with one red light each. It was desired to have these lights controlled so that when the gates were closed or down the lamps would be lighted, and automatically switched off when the gates were raised.

The wire on the gates was run in conduit and the joints in the underground conduit leading to the supply were carefully white-leaded to keep out water. For controlling the lights, a push switch such as is used in clothes closets, was installed as shown in the accompanying illustration. With this switch the circuit is open when the plunger is pushed in. Consequently, when the gates are dropped the lamp circuit is completed, but no current is used when the gates are up.

When this crossing gate is up, the switch automatically opens and puts the red light out.



CHAS. A. PETERSON.

Chief Electrician,
U. S. Gypsum Co.,
Alabaster, Mich.

How to Use Relations Between A.W.G. Wire Sizes

THE American Wire Gage (formerly Brown & Sharpe gage) has a constant ratio between the different characteristics in the different sizes. The wire diameters vary in geometrical progression in the successive sizes; consequently, the cross-sectional area of one size is a constant times that of the next size. When the variations between the successive sizes or the constants are known, and also the properties of one size of wire per 1,000 ft., it is a comparatively easy matter to approximate very closely the properties of any other size of wire.

It will be remembered that No. 10 bare copper wire has a diameter of 0.1 in., a cross-section of 10,000 circ.mils, a resistance of 1 ohm per 1,000 ft. and a weight of 31.4 lb. per 1,000 ft. These relations are approximate. For calculations requiring exact values a wire table must be used.

It will be noticed that for each successive size all characteristics, except the diameter, increase or decrease in a ratio of 1 to 1.26, the ratio between the successive diameters being 1 to 1.12. The area, resistance, and weight are doubled or halved every third gage number and the diameter at every sixth gage number. For an increase of ten sizes the area, resistance and weight are multiplied or divided by 10. By the use of a slide rule it can be quickly noted that the cube root of 2 is 1.26 and that 1.26 squared is 1.59. The first constant is the ratio between successive gage numbers and the second or 1.59 is the ratio for every two gage numbers. It is suggested that 10,380 be remembered as the circ.mil area of No. 10 wire, because this will be the foundation upon which the whole wire table may be constructed. Any added refinement used at the start of the calculations will help to keep the error at a minimum. It is only necessary to extract the square root of the area in

Resistance of Copper Wire

Gage No.	Ohms per 1,000 Feet.		
0	.1		
1		.126	
2			.159
3	.2		
4		.25	
5			.32
6	.4		
7		.50	
8			.64
9	.8		
10	1.0		
11		1.26	
12			1.59
13	2.0		
14		2.5	
15			3.2
16	4.0		
17		5.0	
18			6.4
19	8.0		
20	10.0		

circular mils to find the diameter of the wire in mils. This is true because one circular mil is defined as the area of a circle having a diameter of 1 mil or 0.001 in.

By using the following rules, it is possible to find the characteristics of any size wire and the foregoing short cuts which are more or less commonly known should be kept in mind. To find:

(1) Pounds of wire per 1,000 ft.: divide the area by 330.

(2) Feet per lb.: multiply by 1,000 times the reciprocal of lb. per 1,000 ft.

(3) Ohms per 1,000 ft.: divide (10.37 × 1,000) by the area.

(4) Feet per ohm: divide area by 10.37; or multiply by 1,000 times the reciprocal of ohms per 1,000 ft.

(5) Pounds per ohm: divide lb. per 1,000 ft. by ohms per 1,000 ft.

(6) Ohms per lb.: divide ft. per lb. by ft. per ohm.

Basing our calculations on the fact that No. 10 wire has an area of 10,380 cir.mils, the several properties of different sizes of wire have been calculated on a slide rule and the results obtained will be tabulated as follows:

From Rule (1), 10,380 ÷ 330 = 31.4 lb. per 1,000 ft.

From Rule (2), (1 ÷ 31.4) × 1,000 = 31.8 ft. per lb.

From Rule (3), 10,380 ÷ 10.37 = 1,001 ft. per ohm.

The same result may be found by taking 1,000 times the reciprocal of the ohms per 1,000 ft., or (1 ÷ 0.999) × 1,000 = 1,001 ft. per ohm.

From Rule (5), 31.4 ÷ 0.999 = 31.4 lb. per ohm.

From Rule (6), 31.8 ÷ 1,001 = 0.0317 ohms per lb.

Suppose that a No. 6 wire is the next size that is to be calculated. The area of this wire may be found by using a short cut method. Thus a No. 7 wire has twice the area of a No. 10 wire and No. 6 wire has 1.26 times the area of No. 7 wire. The area of the No. 6 wire can now be calculated thus: 10,380 × 2 × 1.26 = 26,200 cir.mils. The other desired characteristics may be calculated in a manner similar to the above procedure.

The constant 10.37 that has been used in the above rules is the resistivity of annealed copper which is considered as having 100 per cent conductivity. This constant 10.37 is the resistance of a rod of copper 1 ft. long and having a cross-sectional area of 1 cir.mil at a temperature of 20 deg. C. or 68 deg. F. The values in this discussion are based on the resistance at 20 deg. C. and 100 per cent conductivity. The tables in the Standard Handbook for Electrical Engineers, pp. 241-244, were used as a standard.

Another easy method of approximating the number of ohms per 1,000 ft. of wire is given in Circular No. 31 of the Bureau of Standards. Starting with the resistance per 1,000 ft. of No. 0 wire as 0.1 ohms, No. 1 wire has a resistance of 0.126 ohms and No. 2 wire has a resistance of 0.159 ohms. Thus, if occasion requires, it is easy to construct a table showing the resistance of different sizes of wire.

CHAS. F. CAMERON.
Rock Springs, Wyo.

Draining Static Electricity from Color Printing Press

THE operators of a large color printing press experienced considerable trouble due to static electricity.

Static electricity may be induced by friction, and hence sometimes spoken of as frictional electricity. By waving a sheet of paper in the air enough static electricity can be generated to be detected by delicate instruments. In the case of a printing press, the continuous travel of the paper web at 550 to 600 ft. a minute causes the collection of heavy charges of electricity. At times the pressure on the paper due to static is so great as to deflect it from its normal course of travel and thus cause trouble.

To eliminate the static on this press, bare copper wires were first placed at a right angle to the travel of the paper web, about ½ in. below the paper, and grounded to the press frame. This gave some relief from the static but it was not a cure. Then, Christmas tree tinsel cord of about 1-in. diameter was tried in place of the bare copper wire, with results that were remarkably successful.

Two copper wires, wrapped with tinsel and grounded on the press, were placed below the paper web, to drain off the static.

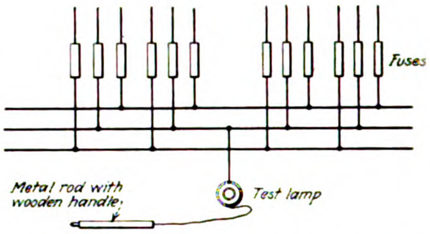
Then, two No. 14 solid, bare copper wires were wound together with the Christmas tree tinsel and placed 1 in. below the paper web, as shown in the accompanying illustration, and grounded to the press. The copper wire provides the necessary mechanical strength to stretch the tinsel tightly across the press and make a satisfactory ground connection. This arrangement has eliminated all static trouble.

Engineer, E. H. LAABS.
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Simple Method of Locating Blown Fuses on Panel Board

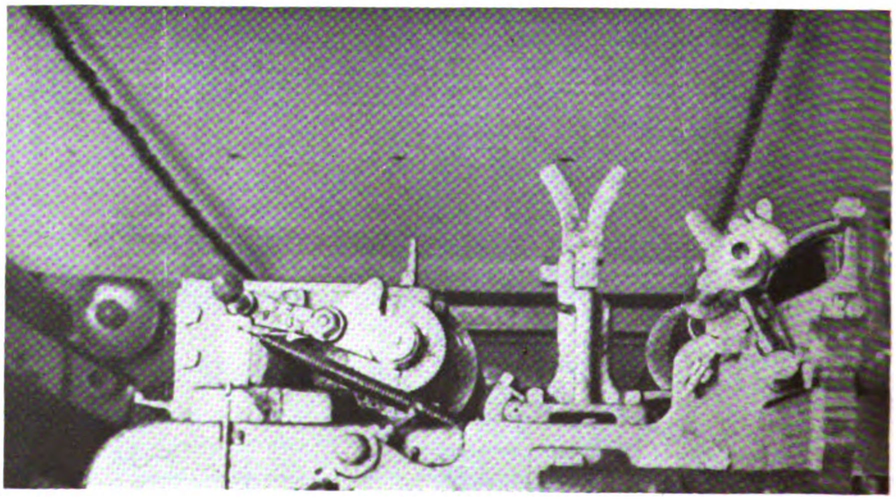
A PERMANENT test lamp will prove to be a saver of time, as well as the annoyance of hunting for a portable tester, on an installation where several sets of lighting fuses are grouped together. The connections for such a permanent test lamp are shown in the accompanying diagram.

In making up this tester, one terminal of a porcelain receptacle is con-



With a permanent test lamp connected as shown a defective fuse may be found by touching the rod to the different fuses in turn.

nected directly to the grounded main conductor. To the other terminal of the receptacle is connected a suitable length of flexible cord, terminating in a metal rod. This rod should be fitted with a wooden handle having an eye screwed into its upper end. In practice, the rod is simply grasped by the handle and touched to the different fuse ferrules until the defective fuse is found. The screw-eye in the handle is for the purpose of hanging the rod up when not in use. JAMES P. MARSHALL.
Providence, R. I.



Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Improperly Bored Bearing Causes Trouble

AFTER new bearings had been installed a 20-hp. motor in a woolen mill would not get up to normal speed. Even the operators on the group of machines driven by the motor noticed the lack of speed and called attention to it. Investigation traced the trouble down to the new bearing at the pulley end of the motor. The repairmen in the mill made it a point to keep one, and sometimes two, bearings ready for each of the motors. When the bearings got worn so that there was danger of a rotor dragging, new ones were put in and the worn ones sent in to the maker for rebabbitting or exchange. This is the most economical practice, particularly in small plants which do not have the proper facilities and but little of this type of work to do.

In this case the new bearing had not been bored true with the outside of the shell. In making the replacement, the mechanic had noticed that the head had gone on with difficulty; so he had pulled it off, micrometered the shaft and bearing, found them all right, and then made sure that all surfaces were clean and free from bruises before assembling again. The bearing seemed to be stiff, but the man was alone and he had not thought it worth while to call the chief, as he believed that the bearing would run itself in, which it did not do.

Emergency measures were necessary in order to keep the motor operating. The hole had been bored diagonally through the shell through some shop laxity that would not ordinarily be anticipated. It was necessary to scrape out the bearing, halfway in from each end on two opposite sides, until the shaft turned freely. This gave sufficient bearing surface to keep the motor going until a new bearing was secured.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Flexible Drive Solves Fan Operating Problem

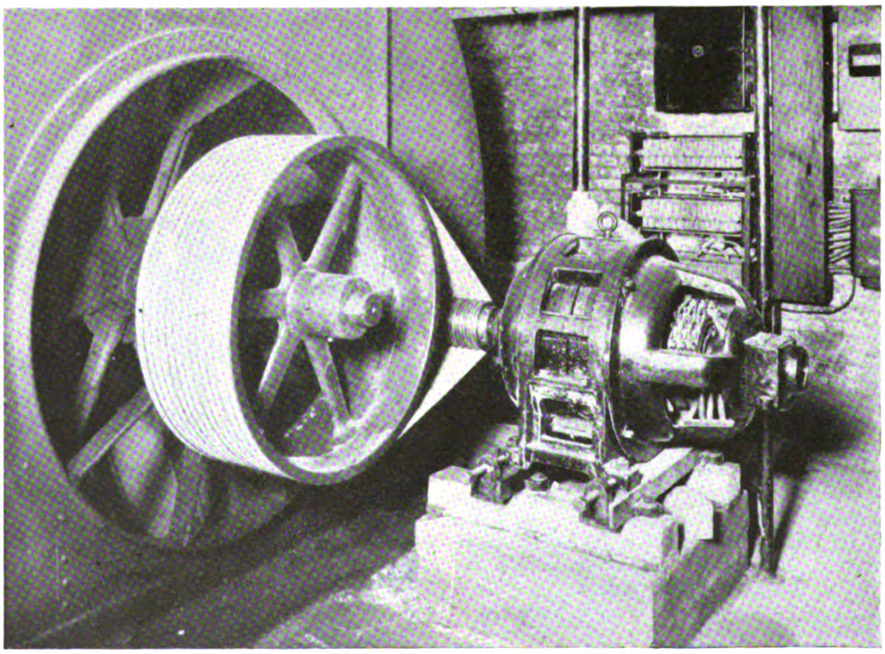
IN MANY cases a satisfactory type of drive for one class of service will not operate so well under different conditions. Probably one of the most severe service conditions for many drives is shock load. Mechanical drive elements that do not provide sufficient flexibility to take care of the shock are not only subjected to the effect of the shock, but pass it on to the bearings. As a result, the mechanical element of the drive either breaks or is hammered to pieces, unless a unit of extra size or strength is provided, or the next weakest link of the drive gives away.

In such cases the inclusion in the drive of a flexible unit that will absorb this shock has solved the transmission problem in a number of instances. For example, a brick plant recently installed a steam engine to drive a large exhaust fan. The engine and fan were connected on close centers by a metallic, inflexible drive. Due to the sudden changes in load, the fan would run ahead of the engine at times and then, as the load came on, would tighten up with a snap, with the result that the drive would soon be pounded to pieces. A flexible drive of the Texrope type (Allis-Chalmers Manufacturing Co., Milwaukee, Wis.) was installed with good results. Sudden load changes are absorbed by the flexible drive with little or no bad effect, it is stated. The change also provided considerable relief for the engine and fan bearings.

In making changes such as this in a drive, care must be exercised to see that flexible units of sufficient size are used and that they are strong enough to absorb the overload due to the shock. This means making an allowance in the rating. Where the shock is severe, it is seldom sufficient to substitute any of the various types of flexible drive units without providing the necessary overrating.

Still another advantage of flexible drives on fans is their silent operation, which is an important consideration when the fan is located near factory or other offices, in schools, theaters, and so on. The accompanying illustration shows such a drive with a 50-hp. high-speed motor, connected to a low-speed fan by a $\frac{7}{8}$-in. Texrope belt. The sheaves are 6 in. and 38 in. in diameter on motor and fan respectively. Shock load is not such an important consideration in this particular fan drive, but any small shock due to slight fluctuations in the load would add to the noise of operation if not absorbed. The motor is mounted on blocks insulated from the foundation, as shown, to absorb the motor hum and so decrease the noise.

Silent, flexible Texrope drive connecting high-speed motor to low-speed fan.



Ball Bearing Hangers Give Over 10-Yr. Life in Flour Mill

THE ball-bearing hangers installed in our mill over ten years ago have been in use 24 hr. per day practically every working day since that time. The original bearings are still in the hangers and with the exception of two hangers out of 55 we have had no bearing trouble in that period. The ball-bearing hangers were installed in order to reduce the friction load and to get away from the oil leakage that goes with the use of the old-type bearings. These 55 hangers are installed on six lineshafts

which drive the rolls, packing machinery and other equipment in our flour mill. The shaft sizes vary from $1\frac{7}{16}$ to $3\frac{7}{16}$ in. and transmit a total of 225 hp. at about 240 r.p.m.

Power is saved through the reduced friction. As our machinery is operated 24 hr. per day the power economy amounts to a considerable figure in the course of a year. If the old bearings were used the power required would probably be at least 10 per cent more than with the SKF ball bearings with which the plant is now equipped.

Savings Effected by Installing 55 Ball-Bearing Shaft Hangers

Power—22.5 hp. × 24 hr. @ $1\frac{1}{4}$c. per hp.-hr. × 300 days		$2,025.00
Labor—greasing and wiping		
With babbitt bearings—5 hr. @ $0.50 per hr. × 300 days	$750.00	
With ball bearings—10 hr. @ $0.50 per hour	5.00	
		745.00
Saving per year in power and labor		$2,770.00

Another item of saving, though not so large, is the reduction in greasing and wiping labor. We grease the ball-bearing hangers twice a year and the total time spent per year in this work is one day. Under former conditions about 5 hr. per day were spent in greasing and wiping. The elimination of oil drippings from bearings is another advantage obtained. No drip cups are required and it is much easier to keep our plant clean. It is very seldom that our new bearings drip any oil in spite of the fact that the original felt washers are still in the hangers.

The old type of bearings on some of our machines throw oil on the belts. On one such machine the life of small belts is only eight months on account of the deteriorating effect of the oil, whereas these belts should last eight to ten years.

Because of the satisfaction given by the ball-bearing hangers, we purchased eight Fairbanks-Morse motors equipped with SKF ball bearings. They vary in size from 5 and 20 hp. with a total of 110 hp. and are driving conveyors, fans and other equipment. Some of the motors are direct-connected to their loads and others drive through belts and silent chains. To date we have not had any bearing trouble with them. We also use ball bearings on seven fans. On one fan the reduction of friction load has reduced the total load and given an appreciable higher speed of the fan. This particular belt drive required much attention previously, but has been functioning very well since the ball bearings were put in.

In the new addition to our plant we have used practically no babbitt bearings and have specified ball bearings on many of the machines; although ball bearings cost more than the old type of bearings they are easily worth the difference in cost, we believe. A total of $2,770 a year is saved by these bearings on lineshafts alone as shown by the accompanying tabulation.

A. G. BECKMAN.
Superintendent,
Pioneer Flour Mills,
San Antonio, Texas.

Individual Drives Give Special Machines Increased Operating Flexibility

EVERY thinking industrial operating man will find that a separate decision as to the type of drive, that is, individual or as one of a group, should be made in connection with each machine. There are cases, for example, where it is advantageous to intersperse individually-driven machines among those which are group driven. The method of driving used in connection with the two small machines shown in the accompanying illustration, and which are used only occasionally, is worth considering in many instances.

Originally these two machines were mounted so that they could be driven from overhead. Their location, however, was not the most convenient for the work; also, they were used only infrequently and were in the way about 75 per cent of the time.

The manufacturing policy in this plant is to handle the parts as little as possible, which means, for them, to finish the parts where they are rather than to have one department do all the milling, another all the drilling, and another the assembling. In the line-up shown in the illustration, small steel pieces are run off the milling machines at the right, from which it is but a step for the operator to place them on the bench, burr off the work, and gage it while the next cut is running.

Certain products which come from these machines have subsequent operations upon them, such as threading, riveting and light bench work which, in volume, can be run through in about one week out of every four. This extra work requires two additional machines. The former practice, as stated, was to have these permanently mounted in place and driven from overhead countershafts.

The type of drive should be selected to give the best operating conditions, as in this case.

Formerly these machines were group-driven from overhead countershafts. However, as they were used only on certain jobs lasting about one week in four, it was thought best to drive the machines individually so that they could be removed when not in use to provide more floor space for other jobs.

Floor space was so crowded that the management wished to make other arrangements and asked the mechanical department to find a better way of handling the work. This was eventually done by rearranging the machines to individual drives by means of the two fractional horsepower motors, as shown. Now, when the time comes to do this part of the work, the two machines are brought out from storage and placed in line so that the machines perform their tasks in the proper sequence as the part moves along.

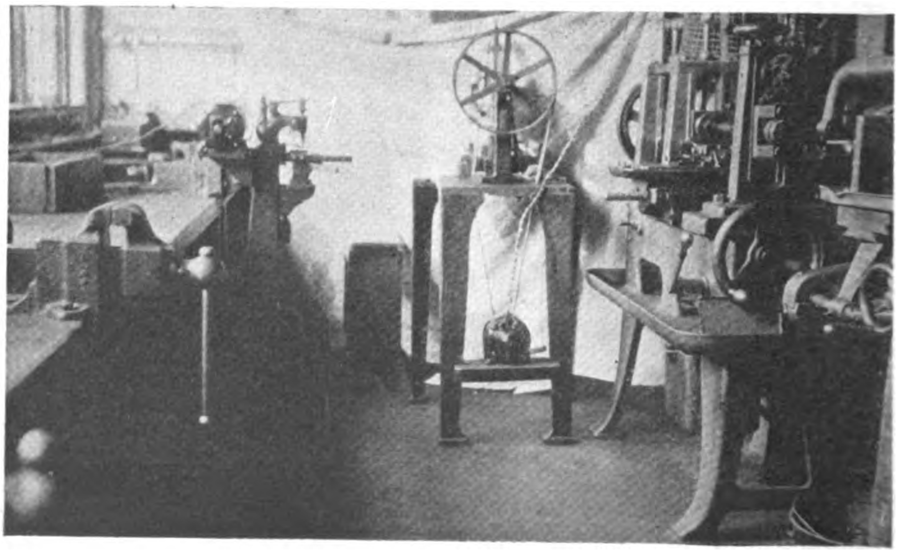
For example, after the bench work is done, the boxes of parts are shoved along to the operator of the little riveting hammer, which stands alongside the bench, who inserts the $\frac{3}{16}$-in. rivet and spins the head over. This machine is driven by a $\frac{1}{8}$-hp. motor which is mounted on a bracket at the rear. The drive is by a short tape belt, sewed endless. A light socket furnishes power.

From the riveter, the parts are handed over to the tapping machine in the center, on which a $\frac{1}{4}$-hp. motor drives the mainshaft. This machine is subjected to rather heavy service, which consists of tapping a $\frac{3}{8}$-in. thread through $\frac{3}{8}$ in. of cold-drawn steel.

When the run of work is over, the plugs are disconnected and the machines trucked back to storage. It does not take over 10 min. to install or remove them. The floor space formerly given over to these small tools is then occupied far more profitably by a heavier machine tool, or is used for other purposes.

In this same small plant six machines are now arranged in this way. Besides the immediate saving in floor space, the machines can be placed in better working positions for light and handling of product. Also, there is a noticeable power saving, because in every case the losses from the lineshaft to the machine were more than the useful power required. In addition, there was a continuous loss when the machines were not producing, which is now entirely avoided. The motors used are all either of $\frac{1}{8}$- or $\frac{1}{4}$-hp. rating and in one instance the same motor is used for two machines.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.



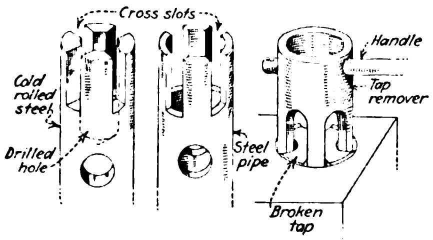
In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

How to Make Handy Tool for Removing Broken Taps

IN MANY cases a tap which breaks off while being used is very difficult to remove because burrs will frequently make it difficult to turn it in either direction.

The tool shown in the accompanying illustration can easily be made from steel pipe or cold-rolled steel bar. With



This tool will make it easier to remove a broken tap.

its help the troublesome, broken tap can be removed without difficulty.

A tool of this kind can be used to remove several different sizes of taps. By inserting the end of the tool into the tap, as shown in the illustration, the latter can be alternately turned to the right and left until the burrs are broken up or pushed aside so that the broken tap can be removed.

Washington, D. C. G. A. LUERS.

Method of Insulating Coils for Semi-Closed Slot Motors

THE service we have obtained from rewound, semi-closed slot stators for a.c. motors has not been very satisfactory until recently, owing to the difficulty of properly applying varnish to the coils after the stator has been rewound. The absence of an impregnating tank and a baking oven in our repair shop has made it necessary for us to devise a method of varnishing the coils before they were installed in the stator.

Several kinds of varnish were tried before one could be found which was suitable for this work, owing to the tendency of the coils to be sticky. This stickiness caused the various turns to adhere to each other and made their installation in the slots almost impossible.

At present when we have a semi-closed slot stator to rewind, the coils are wound in the shape of loops on an adjustable form. The ends of the loops are then taped for a short distance and the coils pulled to shape. If too much tape is used at the ends of the loops, it will interfere with placing the coils in the stator slots. On the other hand, sufficient space must be covered with the tape to enable the coil to hold its proper shape after it is pulled. As soon as all the coils are pulled to shape, they are thoroughly heated to a moderate temperature. While they are still warm, they are dipped in a small tank of varnish and allowed to remain there until completely filled or saturated. When all signs of air bubbles have disappeared, the coils are withdrawn from the varnish container and hung up to drain off the excess varnish. After the draining-off process is finished, the coils are removed to a warm place and left hanging up until they have been thoroughly air dried. The time required to dry the coils properly is 24 hr. They are then ready to be installed.

The time that is required to install the coils by using this method is slightly more than by the old method, but the final results are well worth the time and added expense. Before placing the coils in the slots, the turns are given a coating of parowax. The parowax gives the coils a nice, smooth surface and also causes the turns to pass through the openings to the slots much easier. It is a well-known fact that an application of parowax is beneficial on all winding jobs and most winders make extensive use of it. Coating the coil turns with parowax helps to separate the turns of the coils from each other, but before placing them in the slots, the ends of the loops are taped again for some distance up into the slot itself, in order to be sure that there is no weak point in the insulation near the edge of the laminations.

After the coils are placed in the slots, each individual coil is tested to ground at 2,200 volts before any end connections are made, thus safeguarding against grounds while the motor is operating at its rated voltage. As soon as these tests are completed, all coils are assembled and placed, all of the top wedges are put in, and the remaining end connections are made. When the final tests have been completed the stator is placed on a heating coil and left there for a day or two at a moderate temperature before the finishing coats of varnish are applied.

The final coats of varnish are applied with a De Vilbiss air spray gun, using 40 to 50 lb. of air pressure, to force the varnish into all small crevices and thoroughly seal up the winding. Usually two coats of the varnish are applied with the spray gun, but if the motor is to be used in a particularly damp place, or where it will be exposed to acid fumes, four coats should be applied. Each coat of varnish should be allowed to dry 8 to 16 hr. before the next one is applied, in order that each coat will make a good, hard finish without the application of too much heat.

Motors wound in this manner are giving excellent service in places where moisture and acid fumes are present. Some of our motors that are direct-connected to acid pumps are giving splendid service, even though such service is hard on a motor.

After considerable experimenting, we have standardized on an armature varnish that is used on all of our work. This varnish is manufactured by an English company and is sold under the trade name of Ohmaline. There are several grades of this varnish, but for our requirements, including use with a spray gun and under difficult drying conditions, Ohmaline No. 68 has given by far the best results. For our particular work, no other make of varnish seems to give equal satisfaction.

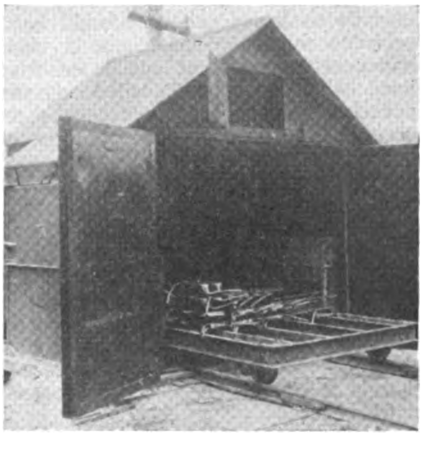
Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

Armature Baking Oven Located Out of Doors

MANY electric railway companies realize the advantage of the dipping and baking treatment for armature and field coils, but some are denied its benefits because of the lack of available space in the armature room, or even in a convenient location for installing the necessary equipment. This was

Outdoor electric oven used for baking armature coils.

A truck is used to carry the work from the shop and to hold the coils during baking.



the situation that confronted us, but we solved it by means of an electric oven, which was placed within 10 ft. of the armature room outdoors, a feat made possible because the operation and control of the oven are entirely automatic. A roof was built over the oven for the protection of the blower motor, which is located on top of the oven, and provides proper air circulation.

The electric oven installed is of Westinghouse manufacture and is equipped with automatic control and operated from a 600-volt d.c. power supply, although it could be arranged for some other voltage if desired. The inside dimensions are 8 ft. wide, 7 ft. deep and 6½ ft. high. Six large armatures can be accommodated at one time. The baking temperature is 230 deg. F., insulation being provided on the oven to prevent excessive heat radiation to atmosphere outside of the oven.

The coils are transported to and from the armature room by means of a four-wheel truck. Before an armature is dipped, all dirt is removed with clean compressed air. Then the armature is heated at a temperature ranging from 95 deg. C. to 105 deg. C. for a period of 12 to 24 hr., depending on the size. This drives out all moisture and warms the armature for dipping. The armature is dipped in an insulating varnish, pinion end down, by means of a chain hoist until the varnish level reaches the neck of the commutator, and is allowed to soak until all bubbling ceases.

After draining at room temperature, the armatures are placed on the oven truck in a vertical position so as to avoid pocketing of the varnish, and baked at 95 to 105 deg. C. for 48 to 72 hr. depending upon the size.

Field coils are treated in practically the same manner. R. C. TAYLOR.

Supt. of Equipment,
The Michigan Railroad Co.,
Albion, Mich.

How A.C. Motors With Defective Coils May be Kept in Service

IN THE event that an alternating current motor has a defective coil, the motor can often be kept in service without rewinding the coil. When the type of connection will permit, both the faulty coil and the one that is diametrically opposite the damaged one, in the same phase, should be cut out of service. If it is also desired to balance the phases, two coils must likewise be cut out of each of the other phases, and the coils that are cut out should have the same respective positions in their phases as the coils cut out in the first phase. Cutting out coils will lower the operating voltage of the motor by an amount depending on the number of slots and of phases in the motor.

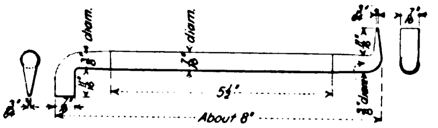
For example, consider a three-phase motor having 96 slots. The percentage of voltage reduction may be determined from the formula: (Number of coils cut out $\times$ 100) $\div$ (Number of coils in the motor $\div$ number of phases) $= 2 \div (96 \div 3) = 6\frac{1}{4}$ per cent reduction in voltage. The reduction in voltage of a three-phase motor having 72 slots and 72 coils will be $(2 \times 100) \div (72 \div 3) = 8\frac{1}{3}$ per cent. Should a motor have 54 slots and 54 coils, the voltage reduction would be 11.1 per cent. In this case the reduction in operating voltage is too great and would cause the motor to run hot. The above formula will apply equally well to two-phase motors.

Muncie, Ind. GEORGE CROPPER.

Simple Screwdriver for Use in Close Quarters

WE ARE all familiar with the offset type of socket wrench used to remove nuts or capscrews located in cramped or inconvenient places, but a screwdriver that will turn machine screws which are similarly located is not so common.

Some time ago we had occasion to remove some machine screws from a



This screwdriver will be found handy for turning screws that are hard to reach.

coupling flange where it was impossible to use a screwdriver owing to lack of space; so we devised a special screwdriver which was forged and made up in accordance with the accompanying diagram. The straight part of the screwdriver, 5¼ in. long, can be knurled to allow a better grip on it.

One end of the screwdriver is shaped to fit into a screw-head slot that runs in the same direction as the shank of the screwdriver, and the opposite end is finished to fit into a slot that runs at right angles to the shank. After it was hardened and tempered, this special screwdriver proved to be very handy for turning many inaccessible machine screws. DAVID FLIEGELMAN.

Worcester, Mass.

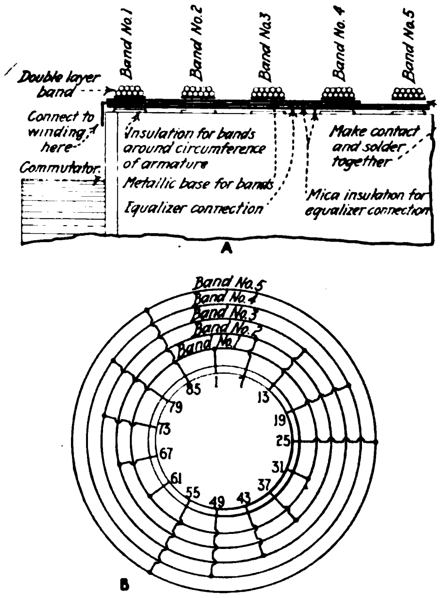
Rewinding Double-Commutator Type Armatures

IT IS occasionally necessary for us to rewind armatures of the double-commutator type and, due to the high speed at which these armatures rotate, their construction is generally such that no space is available behind the commutators to accommodate equalizer rings, which are quite necessary, as the armatures are lapwound.

The armature of a generator which was recently rewound was lapwound and had six poles, 90 coils and slots, and 90 commutator bars per winding. The coils were of the half-coil type, and were made of strap copper. There is, necessarily, between two adjacent commutator risers, a back connection clip which includes 90 commutator risers and 90 clips; so the equalizer connections for each ring have to be spaced 90 $\div$ 3 or 30 slot connections apart, which winding pitch results in a coil span of 1-and-31, for a six-pole winding.

The method of assembling the connections is in accordance with the following procedure. The respective positions of the coil bands, insulation of equalizer connections, and commutator are indicated in *A* of the accompanying illustration. First, we put the insulation strips for the five bands in place around the circumference. Then the equalizer connections, which are strips of sheet copper, are laid across the core from the back connections of the coils to the proper band, being careful to insulate them properly on top and bottom with sheet mica. When this is done, a sheet of strip copper is laid over the band insulation and equalizer connections with the assurance that only the proper equalizer connections come in contact with this strip, after which the band wire is wound on in a double layer. This strip is then soldered to the band and equalizer.

As there are five bands around the core, as shown at *A*, which are necessary by reason of the high speed of the armature and the comparatively large diameter of the core, these bands can be used as equalizer rings; so there will be 3 $\times$ 5 or 15 connections to make between the windings and the rings as indicated at *B*. Since it is necessary to make 90 back connections and 15 equalizer connections, the number of coils from one equalizer connection to the next will be 90 $\div$ 15, or 6, resulting in a coil span of 1-and-7. The coils that



This shows the arrangement of equalizer connections on a double-commutator-type armature.

The method of insulating and connecting the equalizer is shown in *A*. Diagram *B* indicates which bands and coils are connected together.

need to be connected to the bands are, *1, 7, 13, 19, 25, 31, 37, 43, 49, 55, 61, 67, 73, 79* and *85*, as indicated in diagram *B*. These coils should be connected to the bands as follows: Coils *1, 31* and *61*, to band No. 1; coils *7, 37* and *67* to band No. 2; coils *13, 43* and *73* to band No. 3; coils *19, 49* and *79* to band No. 4; and coils *25, 55* and *85* to band No. 5.

The equalizer connections are fastened to the coils by bending the equalizer connections over the edge of the coil connectors and drilling and tapping them for a small-sized screw, after which all connections are also soldered.

Brooklyn, N. Y. MICHAEL REUTER.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Melting Pot

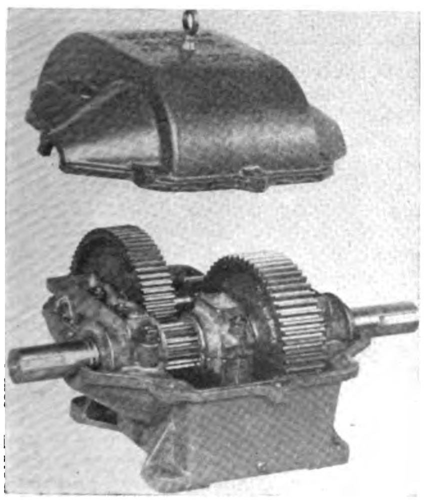
GREATER safety and convenience are two features being claimed for a new electric solder pot, which has been placed on the market by the Electric Engineering Co., Inc., 11712 Atlantic Ave., Richmond Hill, N. Y. This solder pot, known as the Electro Melter, is adaptable to maintenance work in large buildings and factories, and in fact, wherever solder, lead or babbitt has to be melted. This pot, which can be supplied in two sizes—15 lb. and 30 lb. solder capacity—is wired for operation at four different temperatures and can be operated on 110- or 220-volt alternating or direct current.

Speed Reducer

THE Palmer-Bee Co., Detroit, Mich., has recently put on the market a new design of speed reducer. This mill-type speed reducer comprises a set of spur gears mounted on the main drive shaft, the high-speed shaft, and the countershaft, respectively. The high-speed and main driveshafts are axially concentric, and the power is delivered to the driven unit directly on a line with the point where it is received. The machine-cut gears are unusually large, it is claimed.

The bearings are long, cast integral with the bottom half of the casing, and are bronze bushed, as may be noted from the accompanying illustration. All moving parts are lubricated by a patented oil bath, splash and gravity feed system. The entire mechanism is enclosed in an oil-tight and dust-proof housing of rugged design.

The casing is split horizontally on the center line of the shafts, and the upper half, or cover, can be easily removed for inspection of the gears or changing the ratio. The bearing caps are independent of the casing, so that removal of the cover does not disturb the bearings.



New design of Palmer-Bee mill-type speed reducer.

Small Safety Switch

ANNOUNCEMENT is made by the Trumbull-Vanderpoel Electric Mfg. Co., Bantam, Conn., of the marketing of the new 77 safety switch. This is a small, compact unit for direct application to the control of motors up to ¼-hp. rating driving light machinery, such as commercial sewing machines, electric pumps, and so on. The manufacturer states that the switch is only 3¼ in. wide, 5 in. high, and 2⅝ in. deep, not including the bulge in the cover. It is a double-pole, 30-amp., 125-volt polarized switch arranged for single-plug fusing. It is stated that because of the special construction of the end plate, which can be easily removed, or replaced with the switch in position, and is shown just above the illustration of the switch, the wiring and installations are considerably simplified and greatly speeded up.

The New Trumbull-Vanderpoel "77" Safety Switch

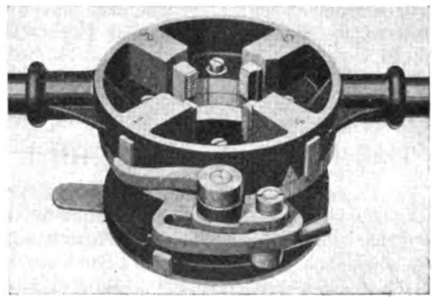
Dry-Plate Air Filter

DEVELOPMENT of a new air filter has been announced by the American Blower Co., Detroit, Mich. The description and principle of operation of the filter are given by the manufacturer as follows: By means of this new filter, which is of the dry-plate design with hairlike tentacles for the arresting and retention of dust and dirt, dust-laden air is divided into a series of small jets which strike the flat, filament-coated surface of the plates, the dust being projected against the filament, seized and retained. The air, changing its direction and rebounding from this surface, flows through to the next plate and is carried through ten successive dust-removal operations of this type. As dust builds up on these flat surfaces each preceding layer acts as a retentive member, the dust first attracted being itself the principal arresting and retaining factor for the succeeding particles. In this way the use of adhesives is avoided, it is stated.

The outstanding advantages of this type of air filter are said to be that it is impossible to clog this filter, that it does not require oil or other adhesives which have to be changed from time to time, that it has a constant effect and constant efficiency, and that dust builds up on dust and does not get in the line of air flow.

Adjustable Diestocks

MARKETING of the No. 70 Series of Beaver adjustable diestocks is announced by The Borden Co., Warren, Ohio. This series is adapted for power drive and is made in five units which range in capacities from ¼ in. minimum to 2 in. maximum, in plain and ratchet types. The unit shown in the accompanying illustration is of the plain type. The dies may be thrown open after the thread is cut, thus saving backing off by hand.



Borden adjustable diestock.
Borden adjustable diestock

Each tool threads several different sizes of pipe without changing dies or bushings and left-hand threads may be cut in the same tool by inserting left-hand dies, according to the manufacturers. The die adjusting cam is beneath the dies. It is stated that the three-jaw universal chuck quickly and accurately centers all sizes of pipe; also, that no locking is necessary.

Wide Range Welding Blowpipe

THE outstanding feature claimed for the new Prest-O-Weld W-101 blowpipe, recently offered to the trade through jobbers by the Oxweld Acetylene Co., 30 E. Forty-second St., New York City, is that it is designed so that the oxygen and acetylene enter the inlets at about equal pressure and are thoroughly mixed in a simple mixing chamber. The mechanical efficiency of this chamber, it is stated, insures intimate mixing of gases under all working conditions, eliminates waste of gases, and saves the time of the operator in maintaining the neutral or working flame.

This new welding blowpipe is of all brass construction and is said to be simple in design. It is screwed together on metal-to-metal seats, with no soldered or packed joints, to facilitate ease of disassembling and reassembling when minor repairs are necessary.

Stems for the W-101 blowpipe are made in three lengths, 4, 9, and 19 in. long, each of which, in turn, is made in three angles, 45, 60 and 90 deg. By un-

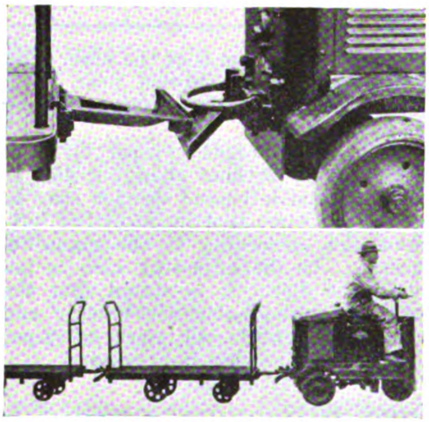
locking one union nut, any one of these stems can be fitted to the handle part of the blowpipe. This feature greatly increases the adaptability of the blowpipe to the physical peculiarities of the work in hand and to the preferences of the operator. The over-all lengths of the blowpipe with the different stems are 15, 20 and 30 in.

The ten interchangeable tips offered with the blowpipe are constructed to withstand the severe service to which welding tips are usually subjected.

The entire W-101 welding outfit complete includes one type R-101 oxygen regulator equipped with 100-lb. and 3,000-lb. gages; one type R-103 acetylene regulator equipped with 30-lb. and 350-lb. gages; 12½ ft. of ¼-in. green oxygen hose with standard I.A.A. couplings; 12½ ft. of ⅜-in. red acetylene hose with standard couplings; one pair of No. 6 fiber goggles, wrenches, and an instruction booklet. The new Prest-O-Weld line also includes the C-101 cutting blowpipe.

Trailers with Automatic Hitch

THE accompanying illustration shows the Clark caster wheel trailer with automatic hitch which is manufactured by the Clark Tructractor Co., Buchanan, Mich. This trailer has a platform size of 3 ft. x 6 ft. and it is 13½ in. from the ground to the top of the platform. The platform is made of hardwood 1⅛ in. thick running crosswise on the trailer and held in place by hardwood bevel sills which are reinforced by steel plates 3 in. wide x ⅛ in. thick.



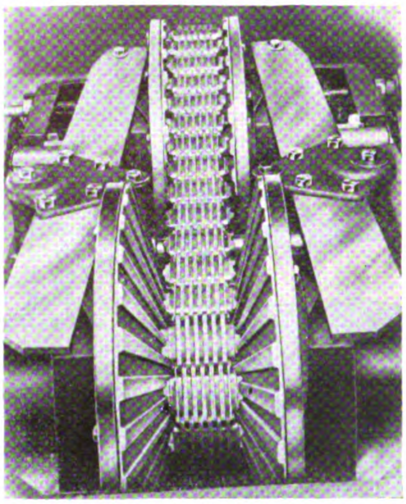
Caster trailer train connected with Clark automatic hitch which is shown in detail in the upper illustration.

Two 2-in. x 2-in. x ¼-in. angle-iron girders run lengthwise underneath the platform, for additional support to the platform board, and also act as supports for the front caster wheels. Eight steel pockets (two on each of the four sides of the platform) are bolted to the under side of the platform for holding in place rails or racks made of 1-in. pipe. The rear axle is supported on heavy steel brackets and reinforced by two additional supports from the angle-iron girders. The front wheels are of the caster type and it is stated that they will trail when in trains. Both front and rear wheels are provided with Hyatt heavy-duty roller bearings and arranged for Alemite lubrication.

The trailers are equipped with a Clark automatic coupler hitch at each end. This hitch is shown in detail in the upper section of the accompanying illustration. These trailers have a rated capacity of 4,000 lb. and weigh 500 lb. according to the manufacturer.

Variable-Speed Driving Gear

ANNOUNCEMENT has been made that the P.I.V. (positive, infinitely variable) variable-speed driving gear, shown in the accompanying illustration, is being manufactured by the P.I.V. Gear Syndicate, Ltd., 7 Princes St., Westminster, London, England, and the world rights are being handled by Messrs. Close Bros., Ltd., Basildon House, 7 Moorgate, London, E. C. 2, who will soon establish an American company to manufacture it. This gear, it is said, allows an indefinite number of speed variations to be given to a driving shaft with positive transmission on any centers, and is adjusted by a single handle.



P.I.V. variable-speed driving gear

The essential principle of the design of the P.I.V. gear is the use of a driving chain of special construction, operating on any center distances down to only a few inches if necessary, which in the standard design runs between expanding pulleys of the opposed, conical-disk type sloping on the inner face to the center, broader at the periphery and narrower at the hub. The two faces are staggered in the sense that a rib is always opposite a groove. The chain is engaged at the edges by these ribs, which act as teeth in such a manner that the drive is said to be truly positive.

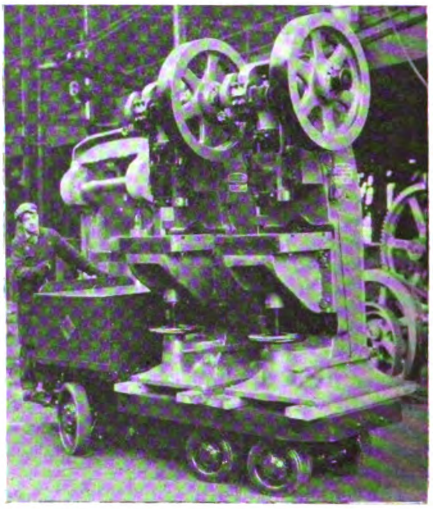
The links are connected by rivets as usual, but a longitudinal slot is punched through them, and in this is fitted a sleeve containing small, thin steel plates or slats fixed vertically and loose in the sense that they can move in a direction at right angles to the travel of the chain. These slats project on either side, and as a link enters the V of the pulleys the ribs or teeth of one pulley face push the requisite number of slats across into the spaces between teeth on the opposed pulley face, so that the chain always engages positively in all positions with the driving pulleys.

Increase in Stock Sizes of Silent-Chain Drives

STOCK sizes of Link-Belt silent chains are now available from distributors in ratings from ½ to 15 hp. in almost any reduction from 1:1 up to 7:1, according to an announcement by the Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill. Formerly the stock sizes carried did not exceed 10-hp. rating. These stock drives do not, the announcement adds, interfere in any way with drives that this company furnishes in sizes up to 1,000 hp. or over.

10-Ton Electric Lift Tructor

ANNOUNCEMENT of the Super-Lift Tructor is made by the Elwell-Parker Electric Co., Cleveland, Ohio, as the latest addition to its mill-type series. This tructor is driven by storage batteries delivering power through Elwell-Parker, drum-type controllers of new design to Elwell-Parker motors. The machine, shown in the accompanying illustration, weighs, complete with battery, approximately 6,100 lb. and, it is stated, will not only pick up but carry 20,000 lb. at the rate of 300 to 400 feet per minute.



Elwell-Parker Super-Lift Tructor

The construction and operation as described by the manufacturer are as follows: The lift mechanism consists of a special motor direct-connected to a single-worm reduction with a nut built into the hub of the worm wheel. A forged multi-thread worm or screw-lift ram travels in and out of this nut, simultaneously lifting or lowering the load. This lift ram is a one piece forging and raises and lowers the heavily re-inforced, all-steel platform.

The tandem trail axle carries four wheels each of which is fitted with two differentiating tires to provide proper creep when being steered. All four wheels steer simultaneously and concentrically with the two larger drive wheels located beneath the battery. Each of the four wheels is fitted with

two heavy tapered roller bearings carried on independent drop-forged hubs with special heat-treated alloy steel knuckle pins within.

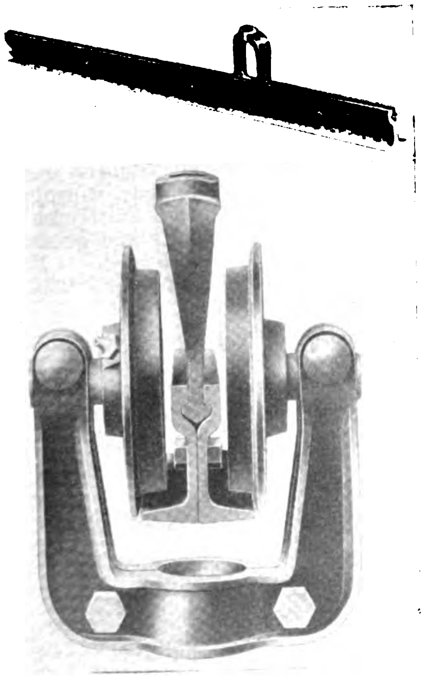
The lift motor is fitted with a special electro-mechanical brake and the complete lift mechanism may be removed from the tructor as a unit. The main drive unit is built with disk wheels on double-row ball, radial and thrust bearings and carries special 22-in. by 6-in. solid rubber tires. Among the applications of this tructor are transferring heavy tools, molten metal ladles, rolls, slabs, pig iron and ingots, as well as handling sheet steel in 10-ton units.

Monorail Track

A NEW and distinctive rail design for overhead hand-power monorail systems is announced by The American MonoRail Co., W. Sixty-seventh St. and Pear Ave., Cleveland, Ohio. Features include a two-part rail, clamped together by means of bolts seated in slotted holes, suspending hangers assembled with the rail, and the elimination of splice clamps by staggering the joint of the two side members of the rail. Unusual carrying capacity which permits wide spacing of hangers and bridging of wide spans is claimed. The assembly of the hangers as part of the monorail sections is stressed as materially reducing cost of installation.

The construction of the rail may be noted from the illustration. It consists of two twin sections rolled from railroad rail steel. The sections are bolted together, back to back, to form a solid rail unit. The high vertical web of the rail is intended to provide maximum carrying strength, while the narrow over-all width dimension of 2 in. facilitates bending of the rail in the field to meet layout requirements. Holes for the clamping bolts are slotted to relieve the bolts of sheer stresses as the sections are being bent. Standard bent sections are furnished for all regular curves and for irregular bends on order.

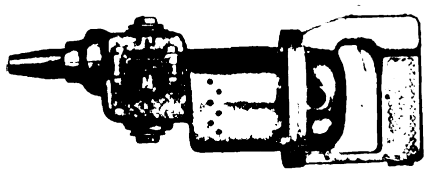
The supporting hangers are steel forgings and are adapted to plain strap or adjustable bolt suspension. They are assembled in the rail head, as shown, and shipped as part of the rail sections. The standard spacing of the hangers can be shifted to meet suspension requirements.



Monorail track manufactured by The American MonoRail Co.

Portable Electric Hammer

MARKETING of the Ajax, portable, Type B-2 electric hammer is announced by the Ajax Electric Hammer Corp., 117 W. Sixty-third St., New York, N. Y. This unit weighs approximately 10 lb., is driven by a universal motor consuming 220 watts, and can be operated directly from any electric lighting circuit. This hammer was designed primarily for drilling and chipping materials, such as brick, stone, and cement, and chipping metals, but it is also adaptable to many other fields. A chuck which holds standard tapered shank drill points fits directly in the hammer and is provided with a handle for rotating the drill while in operation.



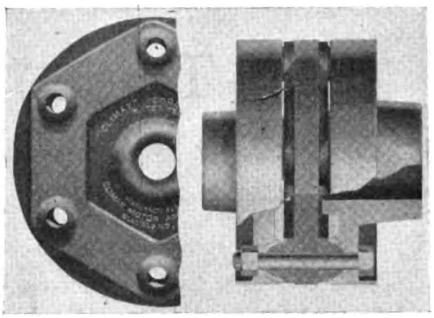
Ajax portable electric hammer.

The mechanism, as described by the manufacturer, consists of only three moving units: motor, crankshaft and plunger, which are housed in an aluminum frame. The crankshaft is driven at right angles to the motor by a 4.75 : 1 bevel gear reduction. Extending from the face or end of the crankshaft is a hardened steel pin and roller which operates in a curved slot cut in the face of the plunger, imparting to it a reciprocating movement. Approximately two-thirds of the revolution of the pin is devoted to lifting the plunger and one-third to throwing it with accelerating velocity against the tool head. As the plunger is thrown and not forced against the tool head no shock is transmitted to the gears or motor. With this method of operation it is claimed that it is impossible to overload or stall the motor and that the hammer delivers approximately 2,400 blows per min. independent of the size of drill or chisel being used. The drilling speed of this hammer with a 1-in. drill in hard concrete is about 2 in. per min., it is stated.

Cord Disk Flexible Couplings

IMPROVEMENTS on the old-type flat disk in a flexible coupling have been announced by the Climax Motor Appliances, Inc., 7016 Euclid Ave., Cleveland, Ohio.

This new Climax cord disk, a section of which is shown at the left in the accompanying illustration, deviates from the old type flat disk in that improved features have been incorporated in the raised cord links extending from bolt to bolt, which, it is stated, add considerable strength and durability.



Left, raised links and semi-spherical bosses on disk. Right, assembly of coupling.

The semi-spherical rubber bosses at the bolt intersection are integral with the disk and are used as driving members. The metal members used in connection are formed to fit the bosses on the one side, and on the reverse side special cup washers are provided, as shown in the cut-away view of the clutch at the right in the accompanying illustration. This construction, it is stated, overcomes the difficulty experienced in using a flat washer by eliminating the critical angularity of the working clearances between the washer diameters; also, this construction makes it possible to transmit the maximum torque without fear of destruction.

These disks are made up for industrial use in sizes from $5\frac{1}{2}$ in. to 16 in. outside diameter, and permit the coupling hubs to be made in various sizes so as to accommodate shafting from $\frac{3}{4}$ in. to 8 in. in diameter. The manufacturer states that power can be transmitted under the most severe conditions, for instance on a fixed angle of 3 deg., on the order of $\frac{1}{4}$ hp. for the $5\frac{1}{2}$-in. disk to 30 hp. for the 16-in. disk, at 100 r.p.m. Under favorable conditions it is stated that the rating could be increased to as much as seven times this.

Water Temperature Regulators for Electric Heaters

A NEW device for controlling automatically the operation of electric water heaters has recently been perfected by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. The control is effected by a Spencer disk thermostat which is actuated by the heated water passing over a thin metal plate placed in contact with the thermostat.

This new thermal regulator consists of the Spencer thermostat mounted in a bronze cast pipe housing above the electric heater. When the heater is turned on, the water passes over it and then through the section of pipe containing the regulator. Until the temperature of the water has reached the upper limit of operation of the thermostat, the heater stays on, but when that limit is reached, the heater is turned off by the thermostat breaking the contact. As soon as the temperature of the water falls below the lower limit of the thermostat, the contact is made again and the heater turned on.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Industrial Lubrication—A 48-page booklet discusses the various types of Alemite fittings and compressors for applying grease under pressure.—The Bassick Mfg. Co., 2650 N. Crawford Ave., Chicago, Ill.

Rawhide Pinions—A 56-page catalog gives numerous tables and rules for the application of rawhide gears. In addition, prices are quoted on gears and gear blanks.—The Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago, Ill.

Industrial Products—Bulletin 43 describes and lists the industrial gears and flexible couplings made by this company.—R. D. Nuttall Co., Pittsburgh, Pa.

Mica Insulation—A booklet entitled, "Micabond—the Modern Mica," describes the various forms of Micabond supplied by this company for electrical insulation.—Chicago Mica Co., Valparaiso, Ind.

Acetylene Welding—The instruction book on the care, operation and use of the No. 6 Smith torch contains interesting and instructive information for all users of acetylene welding equipment. — Smith Welding Equipment Corp., Minneapolis, Minn.

Pneumatic Tubes—Catalog 2175 describes and shows numerous installations of the G & G Atlas pneumatic tube system.—G & G Atlas Systems, Inc., 535 W. Broadway, New York, N. Y.

Fume Recovery—Bulletin 14 describes and shows the construction of the Dracco Twentieth Century baghouse for fume recovery.—The Dust Recovering and Conveying Co., Harvard Ave. and E. One Hundred Sixteenth St., Cleveland, Ohio.

Vaporproof Condulets—Folder 42 illustrates and describes the various conduit fittings made by this company for use around inflammable vapors or gases. —Crouse-Hinds Co., Syracuse, N. Y.

Wiring Devices—Catalog 22 covers the line of wiring devices such as plugline attachments, plates, receptacles, rosettes, sockets and socket switches, and fixture and wall switches.—The Arrow Electric Co., Hartford, Conn.

Chain Drives—Book 812 illustrates and describes a number of applications of Link-Belt silent chain drive for machine tools.—Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

Conveyors—A book of 120 pages entitled, "Bearing the Burden of Industry," describes and illustrates, with photographs of installations and with drawings of the detailed construction features, the installation and application of Mathews roller, sheet-metal spiral, belts and chain conveyors in a variety of industries. A large amount of descriptive data is included in addition to the numerous sketches and drawings.—Mathews Conveyor Co., Ellwood City, Pa.

Angle-Forming Equipment—A circular describes the use of Whitney ball-bearing punches, shears and a special angle-iron combination for punching, cutting, and bending light angle-iron and flat steel.—Whitney Metal Tool Co., 91 Forbes St., Rockford, Ill.

Electric Refrigeration — Booklet AF190 describes and illustrates several different styles and types of Frigidaire water cooling systems for industrial and other use.—Delco Light Co., Dayton, Ohio.

Lubricator—A 48-page booklet gives a description of the use and covers the advantages claimed for the Keystone Safety lubricator. This information is given in the form of questions with answers and descriptions of typical installations.—Keystone Lubricating Co., Philadelphia, Pa.

Material Handling Equipment — A leaflet entitled, "Keep Your Product Moving," illustrates the application of some of the large-sized electric tramrail systems.—The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Line Hardware—An 8-page folder issued monthly under the title, "The Line," illustrates and desecrbies various transmission equipment, hardware, and supplies manufactured and distributed by this company.—Line Material Co., South Milwaukee, Wis.

Babbitt Bearings—Application of alloy No. 25 in the babbitting of bearings is described, and the use of Westinghouse electric babbitting pots is discussed, in Folder 4474.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Power Factor—An 82-page publication, No. 1010, entitled "The Power Factor Book," explains and illustrates from many angles facts that lead to a clear understanding of the meaning and effect of power factor.—The Electric Machinery Mfg. Co., Minneapolis, Minn.

Chain Drive—Folder B-60 entitled, "Fitting the Drive to the Job," illustrates a variety of applications of Whitney silent chain drives. — The Whitney Mfg. Co., Hartford, Conn.

Knife Switches—Reinforced switch and fuse contacts, approved by Factory Mutual Laboratories, are described and illustrated in a leaflet, which also lists the prices of the various types of clips. —Reinforced Switch & Mfg. Co., Pittsburgh, Pa.

Electric Heating Units—Chromalox heating units as applied to airheating are described and illustrated in Bulletin C-108. Bulletin C-106 is devoted to industrial and commercial applications of these heating units.—Edwin L. Wiegand Co., 422 First Ave., Pittsburgh, Pa.

Ball Bearings in Motors—A 20-page book entitled, "Cutting Your Costs, or What New Departure Ball Bearings Mean in Your Motor," discusses the advantages of using ball bearings in motors and gives numerous illustrations of such application, together with economies, which it is said, have resulted from their use.—The New Departure Mfg. Co., Bristol, Conn.

Supervisory Control — A circular C-1694-B gives a clear description of the principles involved in supervisory control and the equipment used.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Condulets—Various types of plug receptacles and safety switch condulets are described and illustrated in Folder No. 43. Bulletin No. 2093 describes and lists the prices of Type MT safety switch condulets.—Crouse-Hinds Co., Syracuse, N. Y.

Clutches—The CM 4 clutch used on a wide variety of low-powered machines is described and illustrated in Bulletin No. 40.—The Conway Clutch Co., 1940 Riverside, Cincinnati.

Self-Starting, Squirrel-Cage Motors —A circular describes the type H-O (Hanson - Oesterlein) self - starting, squirrel-cage motor which, it is stated, has only one rotor winding.—Northwestern Mfg. Co., Milwaukee, Wis.

Gas Heater — An industrial gas heater used for tempering, lead melting, and the like is described and illustrated in a leaflet.—L. J. Van Guelpen Co., Cincinnati, Ohio.

Hand Tools—A 56-page catalog, No. 26, describes and illustrates various kinds of tools for electricians, linemen and mechanics.—Mathias Klein & Sons, 3200 Belmont Ave., Chicago, Ill.

Lubrication of Speed Reducers — Form L-28 gives lubrication instructions for IXL speed reducers of the spur-, herringbone-, and worm-gear types. This publication illustrates the lubrication requirements and gives the grades of oil recommended. — Foote Bros. Gear & Machine Co., 220 N. Curtis St., Chicago, Ill.

Transformer Tap Changers—Bulletin No. 136 describes and illustrates Wagner transformer tap changers as used on large distribution and power transformers.—Wagner Electric Corp., St. Louis, Mo.

Testing Sets—A leaflet describes and illustrates two types of trouble shooter test sets, and test handles.—Universal Test Equipment Co., 2939-41 North Oakley Ave., Chicago, Ill.

Socket Wrench Sets—A folder describes the various types of socket wrench sets for industrial and other work. — Husky Wrench Co., Twenty-Seventh and Florence Sts., Milwaukee, Wis.

Volume 85 New York, March, 1927 *Number 3*

G. A. VAN BRUNT
Editor
D. H. BRAYMER
Consulting Editor

INDUSTRIAL ENGINEER

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

A. J. WHITCOMB
Contributing Editor
F. E. GOODING
G. H. FAIRBANKS
Associate Editors

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Contents

Departments

Improve Your Ability to Express Your Ideas

RECENTLY a concern needed a young man with technical training supplemented by several years of practical experience in industrial plants. The position involved making investigations and preparing written reports, and offered an exceptional opportunity for the future. A number of operating executives in large industrial plants were asked to recommend any likely young men in their department.

In practically every case the stumbling block was the inability of these men to prepare a presentable written report on their work. In one case the head of the department stated that if his assistant could properly prepare a report, he would be worth far more than the concern could pay him as an assistant, and could easily obtain and hold a position as head of the operating department in some other plant.

Ability to prepare reports and recommendations is essential for heads of departments and their younger assistants, if either expects to advance. This ability is obtained only through practice.

The pages of INDUSTRIAL ENGINEER are open to men in industry who desire to try writing their experiences. Published communications are paid for, but the personal benefit to the writer in improving his ability to express his ideas far overshadows the immediate monetary reward.

Why not try your hand on a short contribution for one of the departments?

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

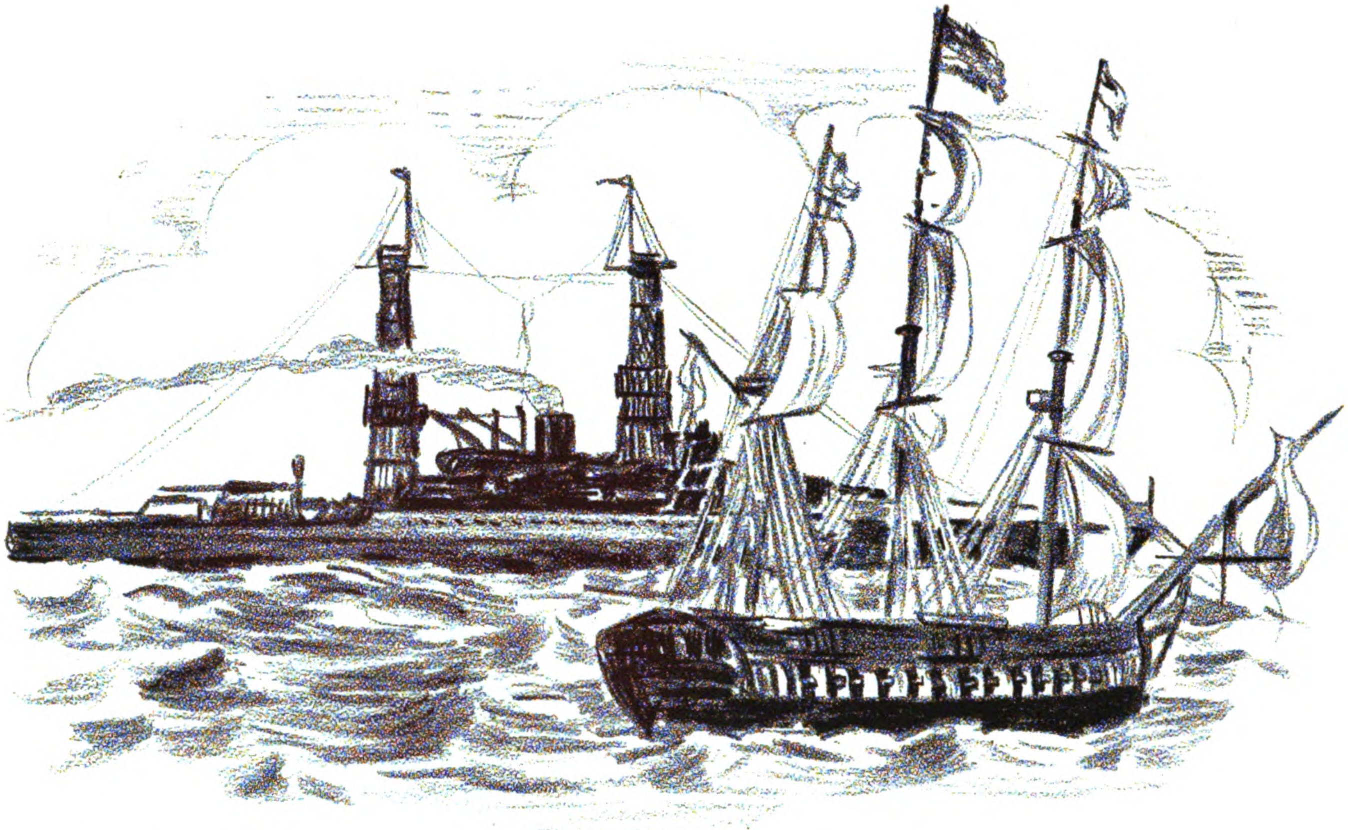
WASHINGTON, Colorado Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4

Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record — American Machinist
Power — Chemical and Metallurgical Engineering
Coal Age — Engineering and Mining Journal
Ingeniería Internacional — Electrical Merchandising
Bus Transportation — Electric Railway Journal
Electrical World — Successful Construction Methods
Industrial Engineer — Radio Retailing
Electrical West
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

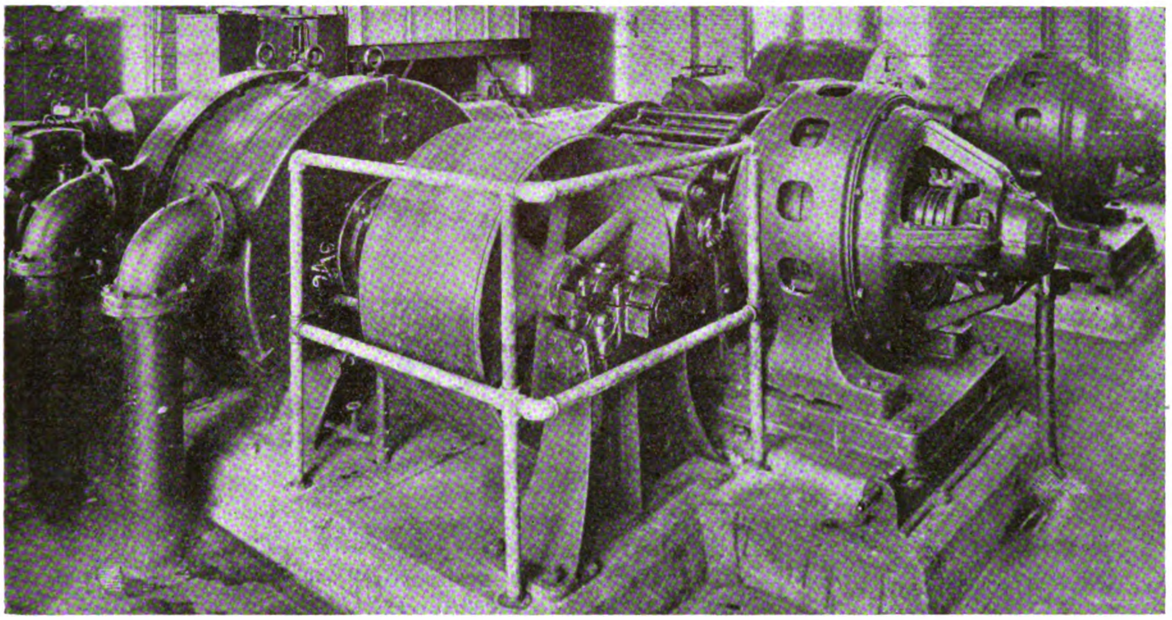
The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Parguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.



INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 85 New York, March, 1927 *Number 3*



Here the motor is mounted almost as close as the equipment will permit it to be.

This motor is driving a 150-hp. Nash compressor, with the two pulleys on 49-in. centers. This Pulmax drive operates 24 hr. a day, seven days a week.

Use of Belts On Motor Drives

By GORDON FOX

Electrical Engineer
Freyn Engineering Company,
Chicago, Ill.

A PREVIOUS article entitled "Using Flexible Couplings on Motor Drives," which appeared in the December, 1926, issue of INDUSTRIAL ENGINEER, was the first of a series on the methods of mechanically connecting a motor to a driven machine or other load. This article discussed the use of flexible coupling and clutches with particular attention to the direct-connected drive in which the driven shaft is in a straight line with the motor shaft.

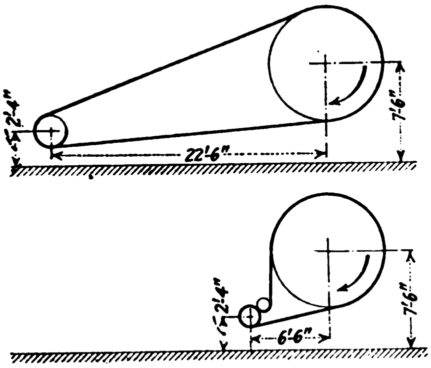
This second article continues the discussion of mechanical methods of connecting up the motor drive where the shafts are parallel, or practically so, and may be several feet apart. These mechanical connections for motor drive may be made by non-metallic links, such as ropes, and leather, fabric-base, or composition belts, or metallic links, such as chains or gears.

The present article will deal with the use of the non-metallic motor-drive links. Of these links, leather belts are the most widely used, although fabric-base and composition belts, as well as a number of belts of special construction, are used on many industrial loads. Ropes are not widely used on motor drives. Belt drives are simple, flexible, inexpensive, and elastic, and afford protection to the motor and machine in the case of overloads and shocks. To a certain extent the belt serves as a safety link for the driven machine, corresponding to the fuse for the motor. In case of excessive overload or sudden stoppage the belt slips off the pulley, usually before the machine breaks. Where the shock load is severe, as on hammer drives, belts of special construction are frequently required.

Some of the disadvantages of belt drives are that they occupy considerable space, are not positive, have relatively high maintenance cost, and are not suited to rapid reversals or other than fairly uniform speed service. The amount of floor space required

for a belt drive may be decreased by the use of short-center belt drive equipment, as is shown by two drawings on this page and many of the accompanying illustrations. This point, however, will be discussed at more length later in the article.

In determining the pulley sizes for a belt drive, the desired ratio and the belt speed are the determining factors. The power that can be transmitted by a belt varies with the speed and increases nearly in direct proportion until a linear speed of about 4,500 f.p.m. is reached. Beyond this, on account of increased centrifugal stresses, the effective transmitting power is reduced. Belt speeds between 2,000 and 4,000 f.p.m. are conservative and represent good

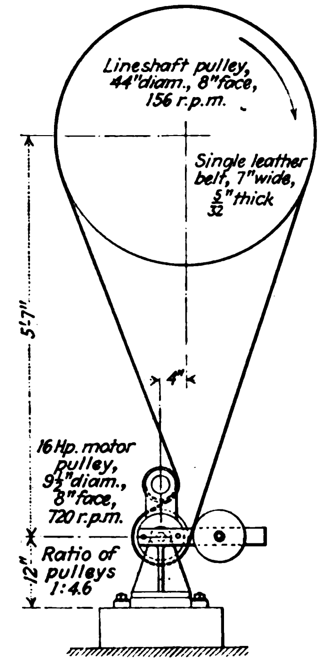


Floor space requirements are one of the objections of the open belt drive.

Long center distances are necessary on open drives to give sufficient arc of contact on the smaller belt pulley. By the use of the Lenix drive, this distance may be shortened considerably, as indicated, and the arc of contact increased. Also, smaller driving pulleys may be used and higher reduction ratios obtained.

operating practice. Ordinarily, about 1,000 f.p.m. is the minimum and 5,000 f.p.m. the maximum operating speed.

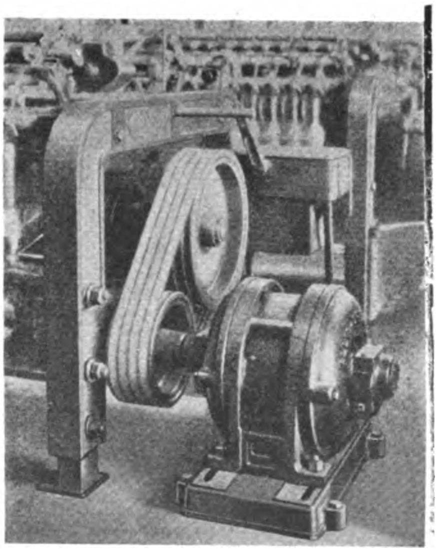
It is most economical to operate belts within the range of conservative speeds, due to lower first cost and maintenance and minimum power loss. Where very low belt speeds are necessary, wider or thicker belts must be used because the horsepower transmitted is dependent upon the speed, tension per square inch of cross-section, and width. Tension cannot be increased beyond certain values without damaging the belt; therefore, as the belt speed is increased or decreased, the width or thickness of the belt must be decreased or increased in the proper proportion if the horsepower transmitted is to remain constant. Also, there is a limit to increases in thickness because of the inefficiency of a



In this case a Lenix short-center drive or gravity idler improves operating conditions on a vertical motor drive.

thick belt over a small diameter pulley.

Diameters of motor pulleys, ordinarily, are kept within rather close maximum and minimum limits for each size of motor; therefore, most changes must be made in the width of the pulley. In case the center of the belt then overhangs the motor bearing a distance greater than the manufacturer has provided for in the design of the bearing, trouble may ensue. A decrease in belt contact surface, due to a decrease in pulley diameter or to short centers with

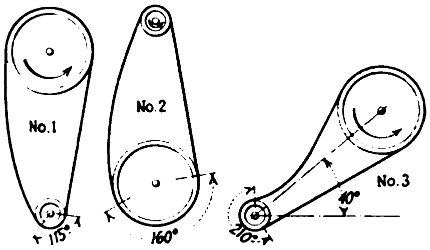


An example of a Texrope drive.

This short-center belt drive in a textile mill consists of multiple strands of a combination rubber-fabric endless V-belt operating in grooved pulleys or sheaves.

high pulley ratios, would require the use of higher belt stresses due to the greater tension required to prevent slipping. There is a limit, however, to the practical stresses usable on account of the physical characteristics of the belt, particularly strength and elasticity.

Wherever possible, the lower side of the belt should be made the driving side so that the sag may be at the top, which increases the arc of contact of the belt on the smaller pulley, providing the angle of the drive is not over 40 to 45 deg. from the horizontal. As the angle from the horizontal increases, an allowance must be made for the decreased pulling power of the belt by increasing the width of the belt, by allowing for the



Three common arrangements of belt drives.

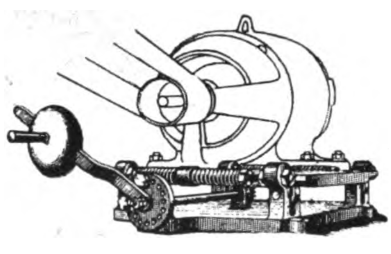
This shows the effective arc of contact of the motor pulley and its belt under different types of service. In the arrangement at the left the small arc of contact calls for extremely high tension or an allowance of about 50 per cent in operating efficiency. Also, the weight of the belt in a long drive would cause the belt to sag and hang away from the lower pulley. The arrangement in the center is somewhat better because the weight of the belt helps it to grip the motor pulley. This, however, calls for an allowance of 15 to 25 per cent. The arrangement at the right is the best, however, but requires an allowance of about 1 per cent loss in effectiveness for every degree over 40 deg. from the horizontal. This illustration is by courtesy of Chas. A. Schieren Company.

decrease in power, or by using a short-center belt drive.

When a belt connecting two pulleys is idle, both sides or strands of the belt are under equal tension. When the driving pulley starts to turn, it increases the tension on one side or strand of the belt and correspondingly decreases the tension on the other side. The difference in these two tensions is the effective pull which transmits the torque and the rotation. In general, under operation, the tension on the tight side of the belt is about three or four times the tension on the slack side. The initial or standstill tension determines the total friction on the smaller pulley which, in turn, limits the possible effective pull. The total pull between the shafts, or the tension on the belt, is the same at all

times, both when idle and when running, and is determined by the initial tension. The transmission of load merely affects the division of the total pull between both sides of belt.

When the two pulleys are on different elevations the weight of the belt adds to the total friction on the upper pulley and subtracts from that on the lower pulley. It is inadvisable to drive vertically by long belts where the lower pulley is the smaller of the two, because excessive tension would be required to maintain a driving contact. This, in turn, increases the maintenance cost and decreases the life of the belt. The difficulties with a vertical drive may be overcome, however, with a short-center drive.



Type of motor mounting recently introduced from Europe.

This Tension Motor Base consists of a movable platform on which the motor is mounted and supported at each corner. Tension is maintained by springs and a counterweight. Horizontal springs are used for horizontal and inclined drives, and vertical springs on mountings designed for vertical drives.

The chart on this page will be found useful for determining pulley and belt data.

Single leather belts should, in general, be used for drives requiring widths up to 7 in. and for use over pulleys less than 10 in. in diameter. Double leather belts should be used for most other installations except for transmitting very large amounts of power, when three-ply belts may be used. Single belts are about 0.25 in. thick and double belts are about 0.35 in. thick. Heavy belts should not be used over pulleys of small diameter because of the sharp bend in the ply.

Rubber belts are elastic and durable, even under adverse conditions of temperature and moisture, have good tensile strength and are uniform in width and thickness; their tendency to stretch, however, is often a disadvantage. The rating of rubber and fabric-base belts is by ply or thickness and, because of the wide variety of methods of construction, the manufacturer's recommendations and ratings should be used in determining a drive.

Laced belts should not be used for motor drives; endless belts are preferable. Belts should run with and not against the lap at the joint, and the joints should be smooth to prevent jarring. The grain side of the belt should run next to the pulley because it is smoother and adheres more snugly, also because the flesh side is less likely to crack. A belt will transmit about 25 per cent more power with less slipping with the grain side next to the pulley.

Wobbling of belts is sometimes due to pulleys having unlike crowns. Other common causes of wobbling or

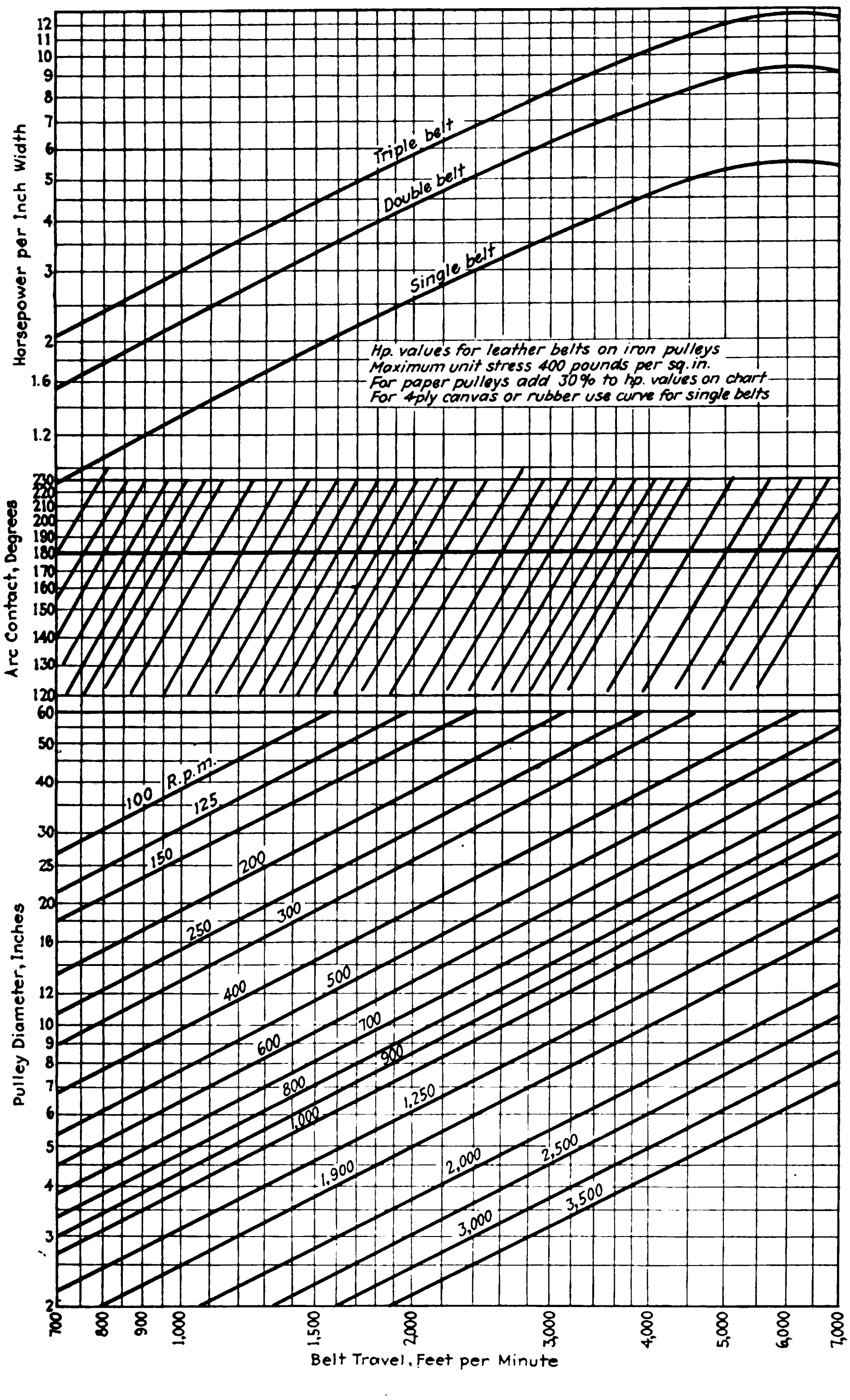
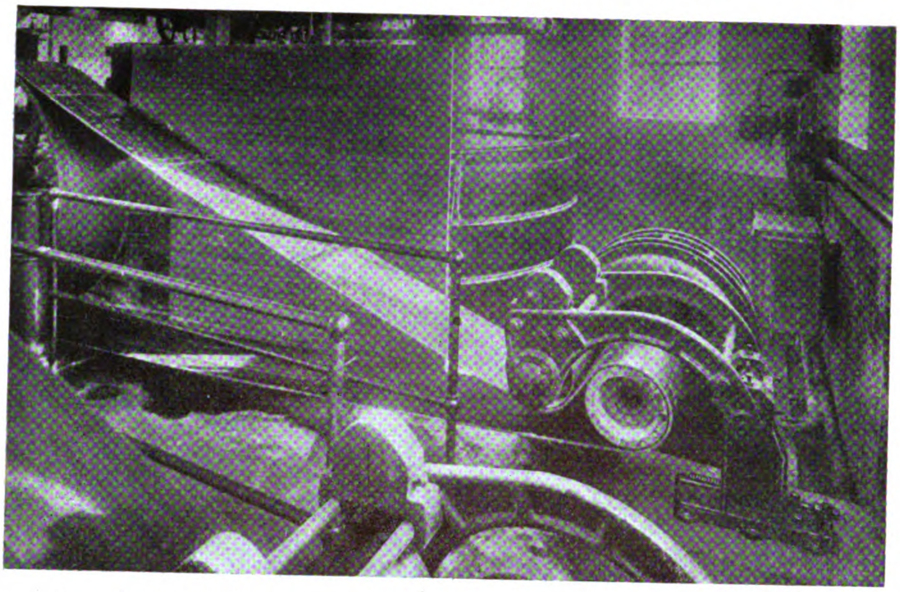


Chart for determining pulley and belt data on motor drives.

Consider that the speed of the driven machine and its pulley size are known. Find the intersection of the horizontal line, representing pulley diameter, and the diagonal, representing speed. The vertical line at this point represents belt travel. Follow this line to the diagonal of motor speed and the intersection will be on the horizontal giving the motor pulley diameter. Returning to belt travel, follow this to the horizontal line representing 180 deg. arc of contact on the smaller pulley, then proceed along the diagonal to the horizontal representing the actual arc for the case in question, which can be readily approximated. Now follow the corrected vertical to the curve for the type of smaller pulley used. The horizontal line at this point will show the horsepower per inch in width of belt which is desirable. From this the values of belt width and pulley face may be determined.



One of two 75-hp. drives in a paper mill.

Originally it was intended to use 435-r.p.m. motors on this drive. However, with the Pulmax drive connection, it was possible to use standard 575-r.p.m. motors at a saving of $190 per motor and an increase in efficiency of 1½ per cent. With special short-center attachments such as this, reduction ratios which would be impracticable on open drives are easily obtained.

weaving of a belt are neglect to make a square joint when connecting the ends of the belt, or more stretch on one edge of the belt than on the other. Flapping is usually caused by slippage between some portion of the belt and pulleys; this may be caused by grease spots in the belt. If the shafts are parallel, but the pulleys are not directly opposite, or aligned, the belt will run to one side of the larger pulley. If the pulleys are opposite, but the shafts are not parallel, the belt will run to one side of the smaller pulley.

The distance between centers of the motor and driven shafts depends upon the relative elevation of the smaller pulley and whether the driving side of the belt is on top or bottom. The distance should be such as to allow a gentle sag on the slack side when operating. Five times the diameter of the larger pulley is usually a safe center distance provided the difference between the diameter of the pulleys is not too great. The center distance has an appreciable effect on the transmitting capacity of the belt on a horizontal or an inclined drive less than 40 to 45 deg. from the horizontal because of the weight of belting suspended between the pulleys. A belt drive with comparatively long center distance, when operating under load, will have more tension on its slack side than a short-center drive. Other things being equal the tension on the slack side of the belt under load is a measure of its capacity.

The following formulas may be used for determining the length of belt required:

For open belts:

$$L = 2\,C + 3.14\,[(D + d) \div 2] + [(D - d)^2 \div 4\,C]$$

For crossed belts:

$$L = 3.14\,[(D + d) \div 2] + 2\sqrt{[(D + d) \div 2]^2 + C^2}$$

Where L = length of belt in feet (not including lap for splice).
C = Distance between shaft centers with motor on near side of sliding base.
D = Diameter larger pulley in inches.
d = Diameter smaller pulley in inches.

In determining pulley sizes the following approximate formula is generally used, in which it is assumed that the rotative speeds of the pulleys are inversely proportional to their diameters; that is, no allowance is made for loss by slip or creep:

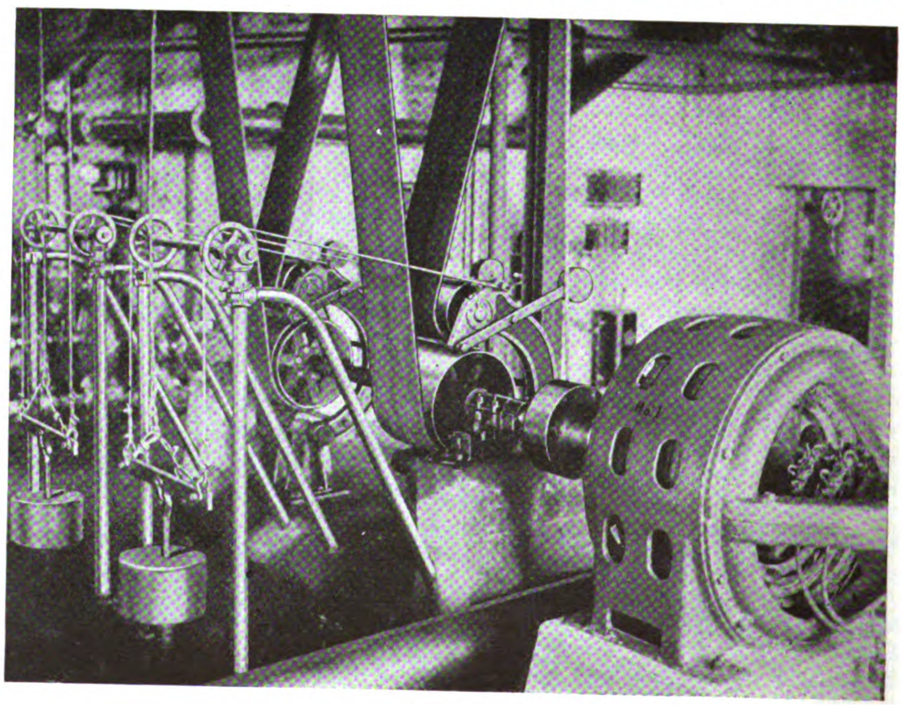
$$ND = nd;\ N = nd \div D;\ n = ND \div d$$

The thickness of the belt introduces a small error in this formula. Where more exact speeds are required the following formula should be used:

$$n = N(D + t) \div (d + t):$$
$$N = n(d + t) \div (D + t)$$

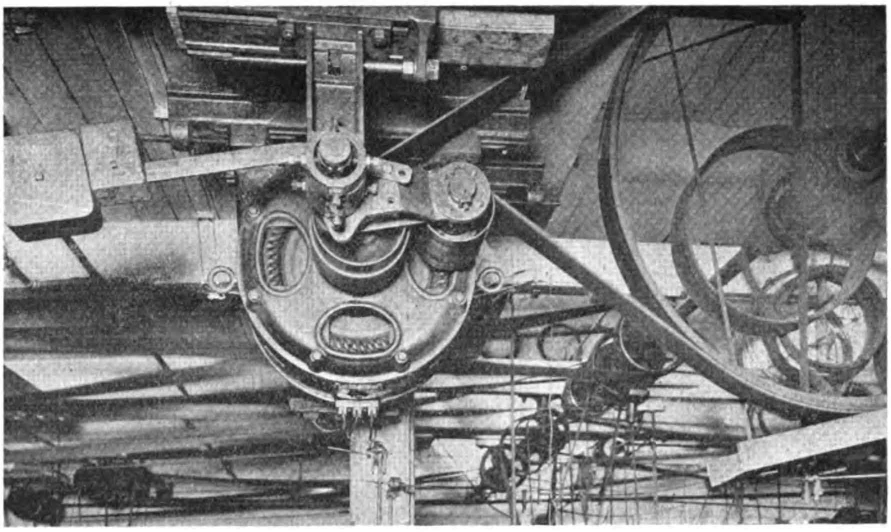
Where N = r.p.m. of large pulley.
n = r.p.m. of small pulley.
D = Diameter of large pulley in inches.
d = Diameter of small pulley in inches.
t = Thickness of belt in inches.

There is always some creep and some slippage that should be allowed for in determining pulley ratios. This is a variable quantity, ranging perhaps from 1 per cent to 15 per cent with an average value on the order of 5 per cent. The maximum advisable ratios of reduction on an open drive through a single set of pulleys are: 8 to 1 for motors of about 5 hp. rating; 6 to 1 for about



Using a vertical belt drive as a starting and stopping device.

When the Lenix drive is not in contact with the belt on this beater drive in a paper mill, the belt hangs away from the motor pulley and the beater is idle. The beater is started by the operator on the floor above, after the motor is running, by releasing the counterweights on the Lenix drive, which tightens the belt on the motor pulley.



This short-center lineshaft drive solved a serious operating problem.
Originally this was operated as an open drive on 19 ft. 3½ in. pulley centers, with the tight side on top. This arrangement was not satisfactory because of slippage. The direction of rotation of the motor was reversed and a crossed belt was tried, which was unsatisfactory because of high maintenance cost. The belt was so tight that when the motor switch was pulled, the motor stopped dead. This Pulmax drive was installed on 4 ft. 6 in. pulley centers with the tight side again on top. It is stated that when the switch is now pulled the motor continues to turn for 1 min. and 20 sec.

10 hp.; 5 to 1 for 20 hp.; and 4 to 1 for about 50 hp.

If it is desirable to ascertain the smallest, narrowest pulley face under which the motor bearings will give service, this may be done by figuring the total belt tension required, according to the following formulas:

For iron pulleys: Tension = (3 × hp. × 33,000) ÷ belt travel in ft. per min.

For wood pulleys: Tension = (2 × hp. × 33,000) ÷ belt travel in ft. per min.

Considering the total tension as applied at the center of the pulley hub, and knowing the distance between bearings and the overhang or distance of the center of the pulley hub from the adjacent bearing, the shaft may be considered as a simple lever and the thrust on the bearing next to the pulley determined. The thrust per unit of projected bearing area may then be figured, if the bearing dimensions are known.

For motors under 50 hp. the pressure per square inch of bearing area should not exceed 70 lb. For large motors, pressures up to 100 lb. are allowable under favorable circumstances. Since belt tension must increase rapidly with a decrease in pulley diameter, motor speed remaining constant, the limitations imposed by the bearings are usually the factors determining minimum diameter and maximum face. Two-bearing motors up to about 50 hp. at 1,750 r.p.m., 100 hp. at 1,150 r.p.m., and 250 hp. at 580 r.p.m. can be used for belted service. Above this capacity a three-bearing motor should always be used.

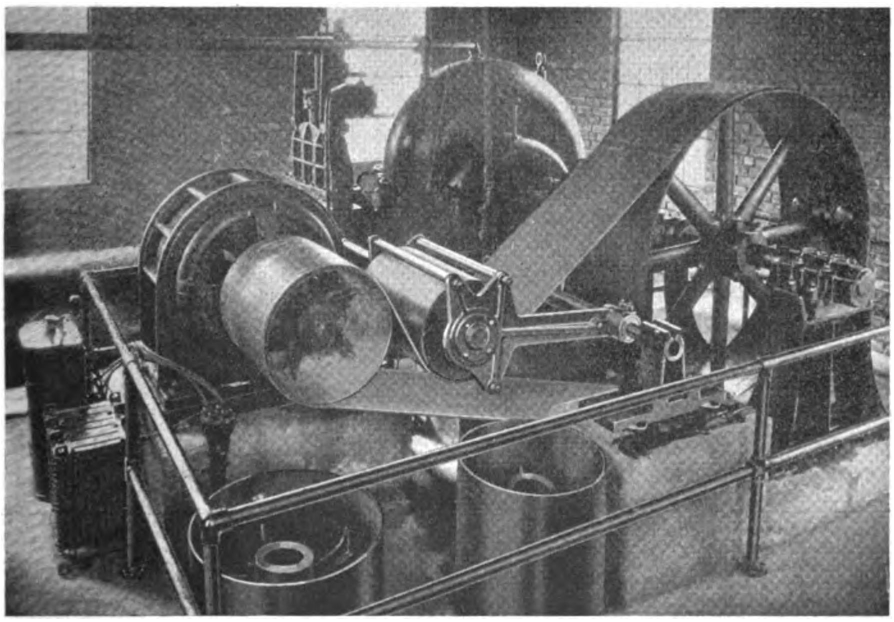
Motor manufacturers have developed a schedule of so-called "standard" pulley sizes which conform with good practice and which may well be used where they may be applied. These standard pulley sizes, with the minimum allowable diameter and corresponding face recommended, are given in pulley manufacturers' catalogs. For belts up to 12 in., the pulley face should be 1 in. wider than the belt; for larger belts, the face of the pulley should be 2 in. wider than the belt.

Large pulleys and those running at fairly high speeds should be carefully balanced by placing them on a mandrel and balancing them on ways. Where the circumferential speeds are very high, special motor pulleys should be used which are manufactured especially for high-speed service. It is well to use gib keys for pulleys (also for pinions) to facilitate removal.

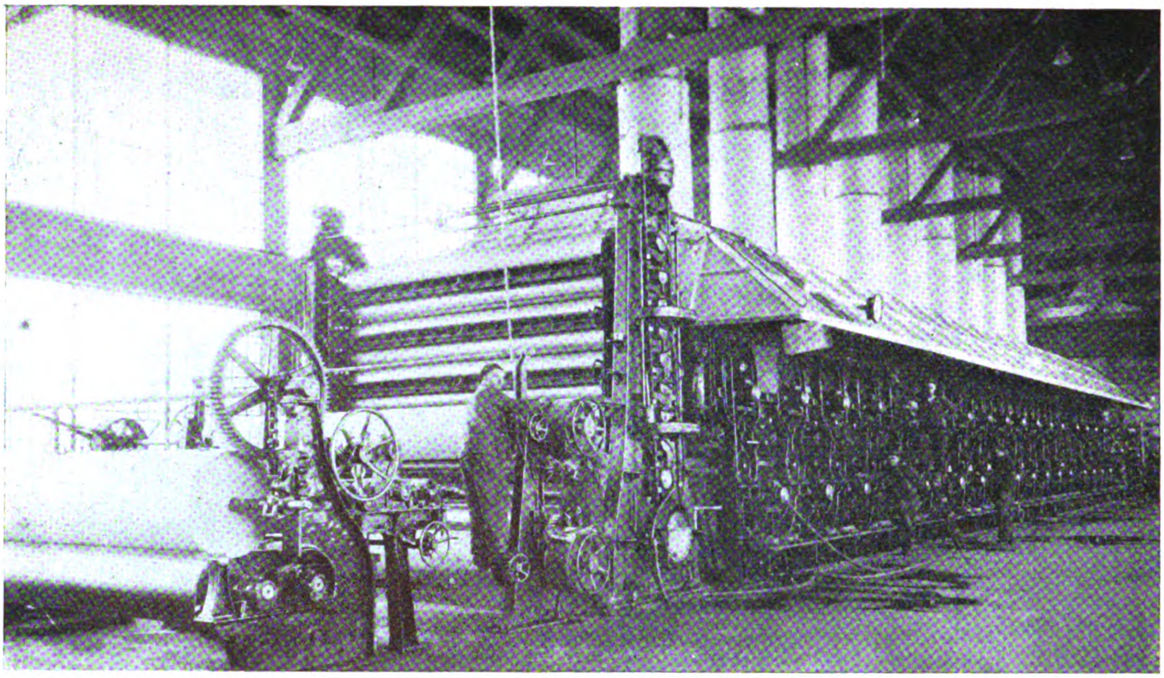
Series motors should never be belted, as the belt is likely to slip off, relieving the motor of load and permitting it to race. As stated before, this characteristic of slipping off the pulley under excessive overload, which slows down the driven equipment to a low point or stops it entirely, prevents breakage in many cases. Where metallic driving links are used, such as chains or gears, some sort of safety link or breaking pin must be inserted to take care of these sudden stoppages. Drives for grinders, presses, or any reciprocating machine which may be choked require a belt or metallic safety link to protect both the motor and the machine.

Many of the objections to belt drives may be overcome by the use of short-center belt drives. These consist of a third counterweighted pulley or gravity idler which is mounted (usually) to ride on the slack side near the smaller pulley of the drive. Screw-downs or fixed idlers are not widely used on motor drives.

(Please turn to page 128)



Obtaining different speeds from constant-speed motor drive.
Here a 200-hp., 860-r.p.m. motor drives a pump at speeds varying from 191 to 310 r.p.m. which are obtained by the use of motor pulleys 22 in. and 27 in. in diameter respectively. Only one endless belt is used. The difference in belt length due to the change in pulley diameters is taken care of by adjusting the motor and the Lenix drive on their respective slide bases.



This is a 164-in., Fourdrinier paper machine, driven by a 300-hp. motor. Push button control of complicated machines like this makes it possible to stop them at once from any one of several stations in case of accident.

Controllers for Electric Motors

By H. D. JAMES
Consulting Control Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

CONSIDERED by itself, an electric motor represents merely power that must be properly controlled and directed before it can be utilized in the most efficient manner. Hence the continual improvement of modern control equipment has enabled it to play a very important part in cutting costs and increasing the efficiency and safety of operating electrically-driven industrial equipment. The intelligent selection and application of control equipment must, however, be based on a thorough knowledge of the designs available, the operating requirements, and the characteristics of the driving motor. This is the first article of a series in which H. D. James will discuss the characteristics and operating principles of the types of control equipment used in industrial plants.

OLDER men connected with industrial activities can well remember the time when electric drive was first being introduced, and the many questions that arose as to the value of electric drive compared with steam and compressed air. In those days even hydraulic power from a central station was considered for certain localities.

All of this is now a matter of history. Today there are very few power applications for manufacturing operations or other purposes where electric power is not used. Central stations have adopted this drive in place of steam for their auxiliary equipment. Vessels on both our inland waters and the high seas use the electric drive for their main propulsion and auxiliary equipment. Even so conservative an organization as the Navy Department has adopted the electric drive for some of its vessels.

Electrification of our steam railroads is taking place as fast as economic conditions will permit. Again, the electric motor has long been used for the pumping of oil wells. It has recently been applied for drilling these wells, making use of a new tool known as the rotary drill, and its success in this field has been definitely assured. By means of this device lower levels of oil can be commercially reached. These are but a few of the many problems that are being solved by the application of electrical energy.

Not only has the electric motor become almost the universal form of drive, but electric power is being used as a heating agent in many of our chemical and metallurgical industries. The electric smelting of steel is well established, and use of the electric oven for enameling work and in bakeries has become quite common. All of these applications require some sort of control for regulating the use of electric power, so that this branch of electrical engineering is rapidly coming to the front as one of its major activities.

It has grown from a handful of men who designed rheostats and drum controllers, until it occupies a place of equality with the other important groups in our largest electric manufacturing companies.

The comparatively rapid growth of the electric drive in industrial plants was based entirely on its economic advantages. Operating men who were familiar with other drives were reluctant to make the change. It was difficult for the older men to understand the electrical problems involved. What we might term industrial inertia operated to retard the adoption of electrical energy. This proved to be an advantage, however, for it made it necesary for the electric drive to prove its worth as it developed.

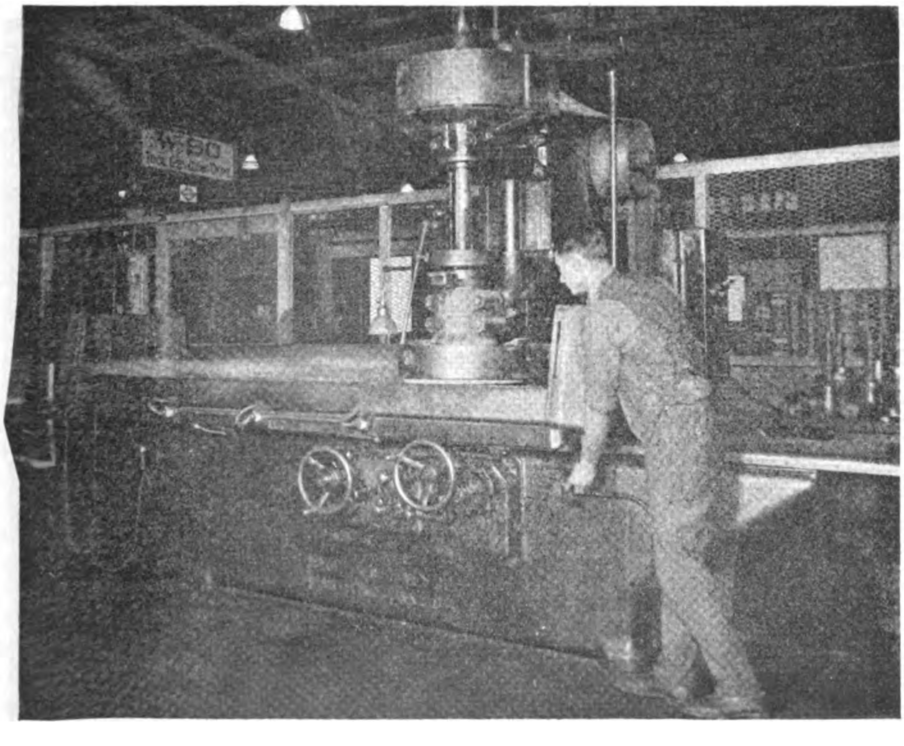
Today we find many progressive manufacturers purchasing new machines and elaborate systems of control, because they can increase the output for a given expenditure of labor and building space. It is this progressiveness on the part of American manufacturers that keeps us the leader of the world in production.

We have all acquired the "push-button habit." At home, we push a button to control our lights; the button also furnishes the power to operate the washing machine, ironing machine, vacuum cleaner and other household devices that are so rapidly taking the drudgery out of the home. In our manufacturing plants, the workman has merely to push a button to start or stop his machine. All of this convenience has been made possible by the automatic controller. The time and energy of the workman have been saved and his person guarded against accident through the ingenuity of the control designer.

When the electric drive was introduced, manual control was used, as this more closely followed the previous methods of controlling power and the mind of the engineer had not yet grasped the idea of automatic control actuated by small master switches or push buttons. Manual control is still used today, and has a real place in the art, but the tendency is strongly towards remote control with automatic features.

In a modern steel mill two operators, who sit in a "pulpit" overlooking the mill, use both their feet and hands to operate master switches which, through the agency of remote control, co-ordinate the speed and direction of the large mill motor and of all of the auxiliary motors, so that the steel billet is passed back and forth between the rolls with almost human intelligence.

Automatic control has made it possible for one person to do the same work that formerly would have required several persons, and to do this work with greater efficiency and safety. It has placed the operator remote from personal danger; so, in case of an accident, he can exercise clear, cool judgment in doing the correct thing promptly.



Modern control equipment has greatly increased the safety and ease of operating machine tools. This is a 22-in. surface grinder that is controlled by a push button which can be seen under the left hand of the operator.

Many of us remember how a workman was formerly required to shift the belt by hand when he wished to change the speed of his machine; in many cases the workman was required to reach across the moving parts of the machine in order to operate the control lever. If, through accident, some portion of his clothing or one of his hands was caught in the machinery, it was almost impossible for him to stop the machine in time to avoid serious injury.

The modern control system provides master switches in convenient places, so that there is little or no danger to the operator in starting or stopping the machine, or changing its speed. Where the process introduces personal hazards, such as are present around rubber mills, paper calenders, printing presses, and other processes in which the workman must place his hands near rolls, the control system provides emergency switches so located that, in the event of accident, the workman can easily stop the machine.

Where larger motors are used and it is necessary to supply a considerable amount of electric power, automatic control permits both the controller and motor to be placed remote from the operator, so that any accident to this equipment will not endanger the workman. The controller can be enclosed or protected if within reach of the workman, to prevent him coming into accidental contact with live parts. This question of safety to persons has been given much careful study by control engineers and means have been provided to protect not only the legitimate operator, but also the curious investigator.

In many cases, the sequence of operation plays an important part in an operation or process. Frequently, the substitution of a mechanical sequence is an improvement over manual operation. The operation of a mine hoist may be taken as an example. As the car approaches the landing, it is necessary to slow down the hoist engine in order to make a safe stop. If the slowing down is initiated by the operator, he will try to be on the safe side and will reduce the speed a little ahead of the time required for making the stop.

If a mechanical device is used, it can be set to initiate the slowdown

when the car is nearer the landing, as it is always operated at the same point. This results in giving the car a greater average speed so that it can make more trips per hour. On one particular application, it was reported that the introduction of an automatic slowdown and stop mechanism increased the number of trips made by the hoist about 20 per cent. If this is true, it is an unusual case, but indicates that considerable improvement may be expected.

Again, many processes require a definite sequence of operation. This can be obtained by interlocking the various controllers so that each performs its function after the previous one has completed its cycle. The function may be automatic or the interlocking may be used only to prevent wrong operation. Thus, in a coal-handling plant, the coal is lifted by a conveyor to a hopper and then passed down over screens and conveyors into different bins. The machinery at the delivery end of the plant is started first and care is taken to see that coal is not fed into machines that are not running. If one section of the machine is stopped, it is necessary to stop automatically the rest of the machinery feeding coal up to that point; otherwise there would be an accumulation of coal at the blocked section that might cause loss or damage. Interlocking features for a plant of this kind are relatively simple and easy to obtain.

An ash hoist that operates automatically through a complete cycle requires a more complicated control. The ashes are dumped into the car, or skip, which then automatically starts up an incline; as it approaches the upper limit of travel, it is slowed down and stopped at the point where the skip empties its contents into a conveyor. After a short interval of time, the motor is started in the reverse direction, returning the skip to its initial position where it is stopped for a given interval while it receives a new charge of ashes. The cycle is then repeated, either by an automatic timing device starting the skip, or by an operator pushing a button.

The car dumper is another illustration of interlocking controllers. The car is first hauled from a siding up to the cradle, where it is clamped in place and hoisted the desired distance. The cradle is then rotated, emptying the contents of the car on an apron where it passes through a chute to a car or vessel. Following this the cradle is returned to its starting place; the car is released, and the mechanical device pushes the car out of the way, so that the cradle is ready to receive the next car.

Many applications will occur to the readers, where the automatic interlocking of control will give the necessary performance, insure safety of operation and, in some cases, provide for automatic sequence.

Before we are ready to consider the control, however, we must select the type of motor most suitable for the drive under consideration. This selection will be limited by the source of power available. If alternating current is employed we are limited to a squirrel-cage motor that operates at certain fixed speeds, or to a motor whose speed can be changed by the use of external resistances, the values of which depend upon the load on the motor. This type of motor is known as a varying-speed motor, in distinction to a motor whose speed remains substantially the same at any load.

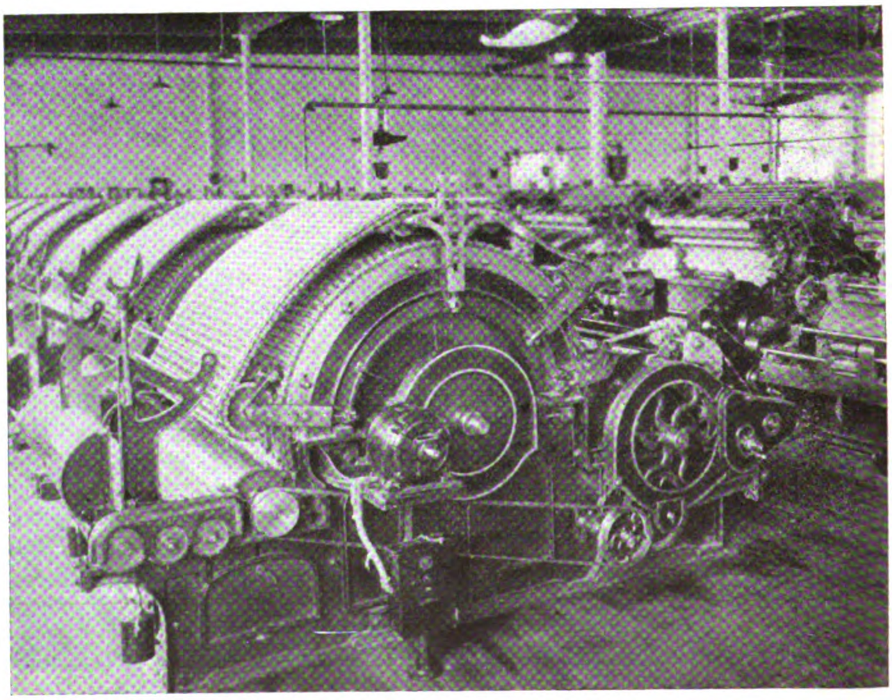
There are types of control for a.c. motors that permit of speed adjustment over a wide range, but such motors and control are complicated and are not used except in large sizes. Types of adjustable-speed a.c. motors have been used in limited number, but need not be considered for ordinary applications. If the nature of the load requires an adjustable-speed motor, a source of d.c. power should be available. Some manufacturing establishments convert all of their power from alternating to direct current, as the latter is a better source of power for their particular applications.

The squirrel-cage induction motor is the one most commonly used where constant speed is required. This motor can be wound to give several different speeds by changing the number of poles, but this is feasible on only very few applications. In general, we can assume that a single-speed motor is used. The control for this motor may connect it directly to line voltage, or a means of reducing the starting voltage may be provided. This latter type of control is usually supplied with the larger motors.

The wound-secondary motor is not used so much as is the squirrel-cage type. It is usually applied to cranes, pumps, fans, air compressors, and the like, where operation at different speeds is desired. If the load remains constant, the speed adjustments are satisfactory. The controller provides a means for opening and closing the power connection to the primary of the motor and means for inserting external resistance in the secondary circuit for starting or speed regulation.

Direct-current motors are used for a great variety of applications, although the total number of such motors in use is much less than in the case of the a.c. squirrel-cage type. This variety of applications presents some of the most interesting problems in control design. Direct-cur-

These carding machines are individually driven by small motors, which are controlled from the push-button station shown in the foreground.



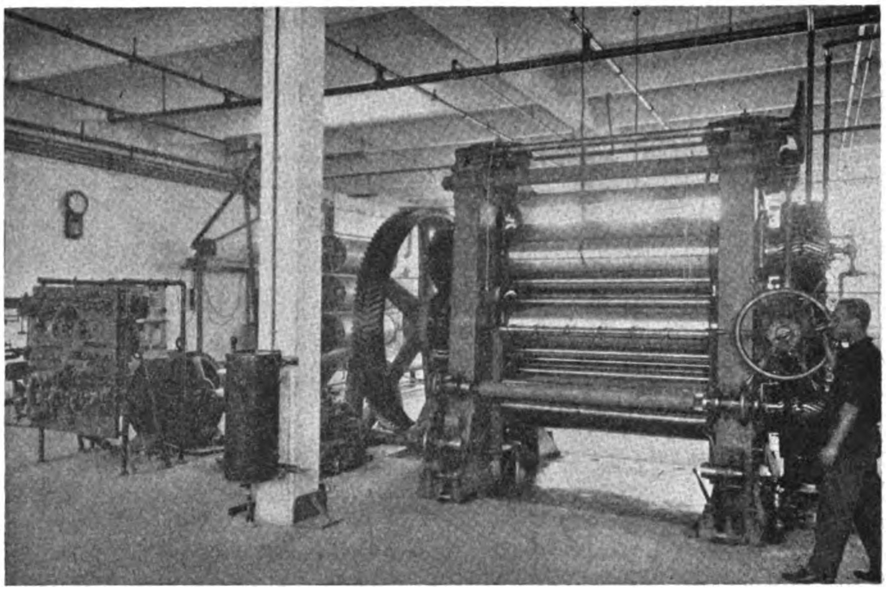
rent motors are available with shunt, series or compound windings on their field. Each type has its particular characteristics, so that it is important to select the correct type for the particular application. The types of control used with these motors are too numerous to be summarized here, but will be dealt with later.

After the most desirable type of motor has been selected, modifications of its characteristics can be studied for a special application. For example, the squirrel-cage induction motor, which is the simplest type of motor in commercial use, has a considerable range of characteristics largely dependent upon the design of its secondary. The general-purpose, stock motor of this type is intended to operate at constant speed and is usually not applied where the machinery is stopped and started very frequently. This motor has a relatively low-resistance, squirrel-cage winding, and takes about six times full-load current if started at full voltage. The larger sizes of motors are, therefore, provided with reduced voltage starters in order to limit the demand on the power system when starting.

This same type of motor can be provided with a high-resistance secondary which gives it much better starting characteristics, although these are obtained at the sacrifice of its speed regulation and its efficiency when operating at full speed. One of the best illustrations of an application using this type of motor is the electric elevator. This service requires the motor to be stopped and started frequently, but it runs for only short periods of time and, therefore, a high, full-load efficiency is not essential.

In designing the motor for this application, it is necessary to give careful attention to the mechanical details. In operating an elevator, mechanical energy is stored in the rotor of the motor during the acceleration period. When the elevator is stopped, this mechanical energy must be absorbed by the mechanical brake. Therefore, a motor having a small-diameter rotor will be much more satisfactory than the standard design. An elevator motor has a relatively long rotor of small diameter.

The continual starting and stopping of the motor first in one direction of rotation and then in the other introduces mechanical stresses that require a rigid construction with well-braced windings. The successful use of squirrel-cage motors for elevators is largely due to the very excellent special designs that have been made available for elevator service.



The 75-hp., double-voltage d.c. motor driving this rubber calender is controlled by the magnetic controller shown at the left.

Laundry machines present another interesting problem. These machines are operated for a few revolutions in one direction, and are then operated in the reverse direction for an equal number of revolutions. The cylinder carrying the wash has considerable inertia and it is, therefore, necesary to limit the torque of the motor at the instant of reversing. On the other hand, considerable torque is required to start the machine from rest. Earlier types of control for these machines made use of a voltage-reducing device, such as a resistor, that was connected in the primary circuit of the motor at the time of reversing, to limit the torque. This method made the control more complicated and increased the cost of the equipment.

A better solution was found in designing the motor so that the torque at reversal is less than the starting torque, which eliminated the resistor and simplified the control. This improvement illustrates what can be accomplished by a careful study of the application.

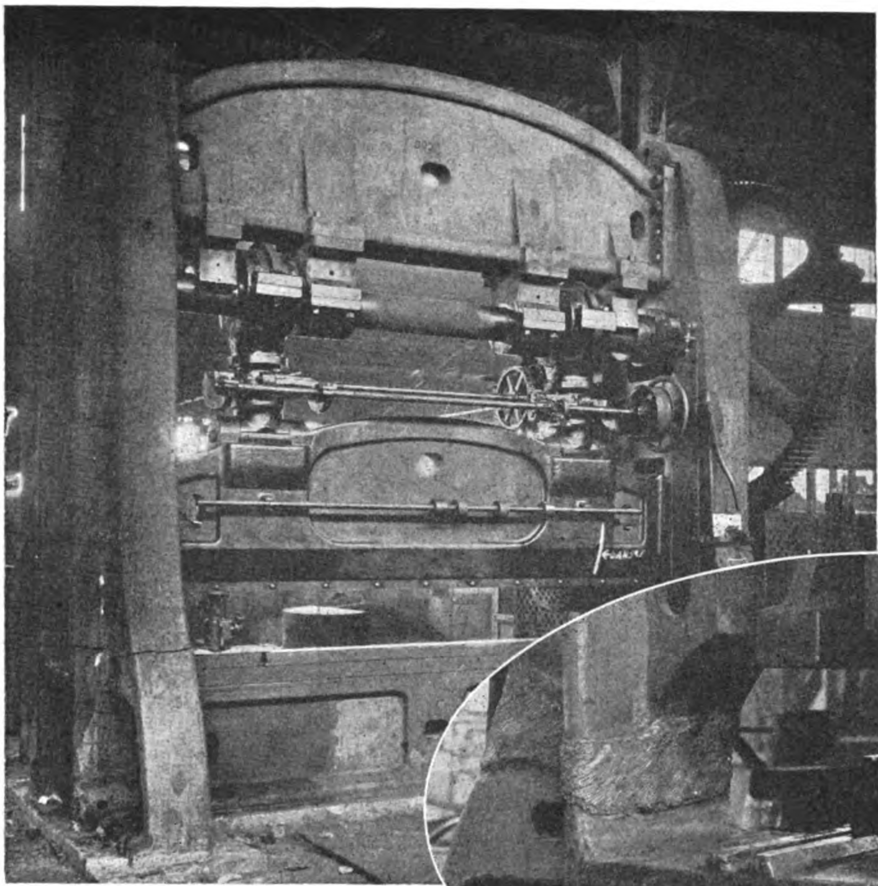
When the reversing motor was first applied to planers, a satisfactory system of control was developed, but the application as a whole was not successful because the proper type of motor was not available, and the machine tool builders attempted to couple the motor that seemed best suited to the service to the existing design of planers. A careful study of the motor and control requirements, as well as the design of the planer, has resulted in such marked improvements that the belt-driven planer is largely a thing of the past.

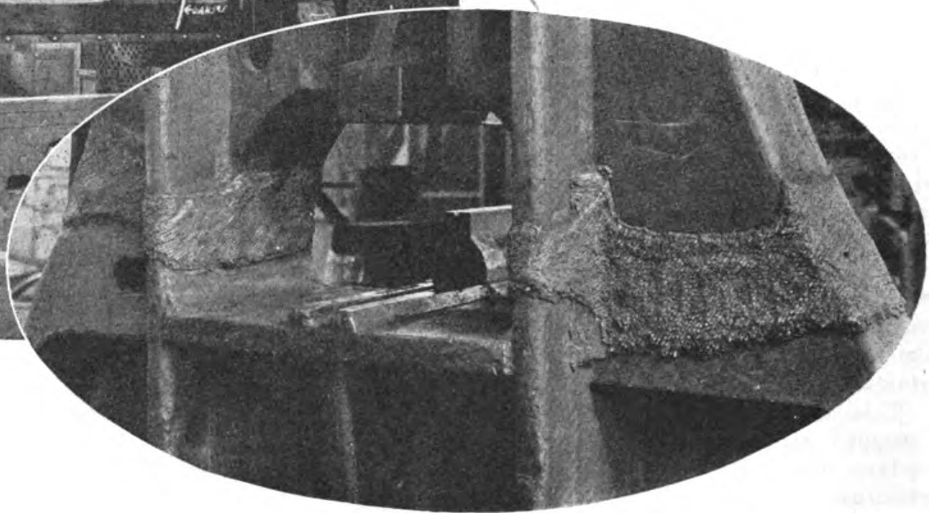
These illustrations are given to show that a successful electric drive may require the co-operation of the machine builder, as well as the electrical designer. Many times the control can be simplified by selecting a motor that has characteristics particularly adapted to the drive. It is the function of the controller to furnish the characteristics that cannot be conveniently incorporated in the motor; therefore, a careful balance should be struck between the motor and control designs to obtain the simplest and most rugged equipment.

By itself, a motor represents uncontrolled power. It must be directed, so to speak, so that the mechanical energy it supplies can be made to do useful work in a prescribed manner. Again, a motor cannot protect itself against overloads, or damage to itself and the driven equipment through operation under improper conditions.

Therefore, in addition to its prime function of properly starting, stopping and, if necessary, reversing a motor, the control may be required to furnish protection against overload, phase failure or reversal, accidental starting on restoration of power after failure, or to provide for restarting after power failure, and perform other functions that are necessary.

The next article of this series will appear in an early issue and will discuss the salient features of the different types of control in industrial use.





By the use of arc welding this large shear was put back in service within 40 hr. after the frame broke.

Electric Arc Welding in Maintenance Work

By ROBERT E. KINKEAD

Chief Engineer, Welder Division, The Lincoln Electric Company, Cleveland, Ohio.

MANY maintenance men have had the experience of seeing carefully planned economies wiped out and maintenance costs go skyrocketing because of unexpected breakdown of essential equipment. The use of electric arc welding has grown rapidly in maintenance work because in many cases it has enabled production delays and repair costs to be greatly minimized. In some plants, the arc welder is regarded in about the same light as a sprinkler system; in fact fire loss can be covered by insurance, which is not the case with sudden failure of equipment.

An accident at the Armour Grain Co.'s elevator at Chicago illustrates very well the value of arc welding in emergencies. The trouble occurred in the autumn three years ago. As is usually the case, this was the time when the elevator was the busiest. Grain was coming from the West as fast as the railroads could bring it. The elevator was working night and day loading ships for Eastern ports and conveying the grain to storage bins.

Right at the peak of this activity, a careless switching crew backed a string of cars through the thin wall of the elevator into the 1,000-hp. Corliss engine driving the conveying machinery. Backing a freight train into a Corliss engine with a 20-ton flywheel going at full speed is, as was shown by this experience, likely to create a good deal of havoc.

A serious situation was brought about, as that elevator had to take the grain from the cars as they arrived, or stand a heavy demurrage loss on both cars and ships. Electric arc welding saved the day. The accident occurred at 7 p.m. on Sunday, and the welding crew started picking up pieces of the bell cranks and putting them in a basket at 9 o'clock the same evening. At 9 o'clock Wednesday morning, the elevator was again operating at full speed.

A 36-in. break in the frame of the engine had been welded, and the bell cranks all put together and welded without the necessity of even remachining them. The connecting

rod and valve rods were straightened, and a weld was made in the outboard bearing pedestal.

No attempt was made to repair the fly-wheel. There was sufficient friction load on the engine to make it entirely safe to operate it, with a man constantly at the throttle.

The welding job was done by The Mitchell Co., a firm of emergency master mechanics that uses welding as a matter of course to save time. This particular firm sends its crews of experts into a plant in distress with the same speed and discipline that are displayed by a well-trained fire department. The crew, under a captain who is an all-around engineer, comes in, takes command of the part of the plant that is crippled and remains in full charge until operation is resumed. Arc welding equipment on motor trucks is called out by telephone as required. Practically all types of equipment are mounted on motor trucks so that it can be brought to the scene of the accident in a matter of minutes.

One important advantage of arc welding is that it permits the repair of heavy gray-iron castings without the necessity of dismantling or preheating. A long time is required to repair heavy shear frames like the one shown in the headpiece at the beginning of this article, if they have to be taken outside the plant and preheated. It took a well-trained crew of arc welding operators 40 hr., working in 8-hr. shifts, to repair the break in the frame of this shear.

Large plants in which heavy production schedules are maintained, find that arc welding equipment is a good investment, that may be considered in the same class as insurance. The Timken Roller Bearing Co.'s plant at Canton, Ohio, is a good example of an organization that protects itself against preventable loss by the use of arc welding.

Pinion seats on rolling mill shafts are built up in the Timken plant at about one-fourth of the cost of new shafts.

Furthermore, machinery that breaks or wears out before its time requires capital expenditure for replacement. By getting longer life out of machinery and equipment, substantial economies are made by the Timken Roller Bearing Co., to name only one example. More spectacular management economies have been effected than those accomplished by extending the useful life of expensive metalworking machinery, but from the stockholders' point of view careful conservation of capital invested in machinery is evidence of intelligent management.

In this plant, the machinery and equipment used in the manufacture of the product are, in many cases, built especially for the purpose. Failure of this machinery by breakage or through wear was formerly the cause of serious and costly delays in the production schedules. Special machinery parts take a long time to obtain and are very expensive when they do arrive. Timken maintenance engineers have provided a well-equipped welding department for quick repairs and can now have broken and worn parts welded within a few hours. Both arc welding equipment and gas welding torches are available in the welding department, in which highly-trained operators are employed.

These annealing boxes are made and maintained by the use of arc welding.

By welding cracks and air leaks as soon as they appear, these boxes can be made to give two or three times the length of service that would ordinarily be obtained.

A rather striking example of the economies effected in this plant by emergency welding repairs occurred recently in connection with a repair job on a 50-ton draw bench. Tension is applied by a massive chain that passes over a sprocket on a shaft, which in turn is driven through a set of gears by a 100-hp. electric motor. The drawing head is used to size heavy tubing, preparatory to cutting it up into sections from which the outer roller bearing races are made.

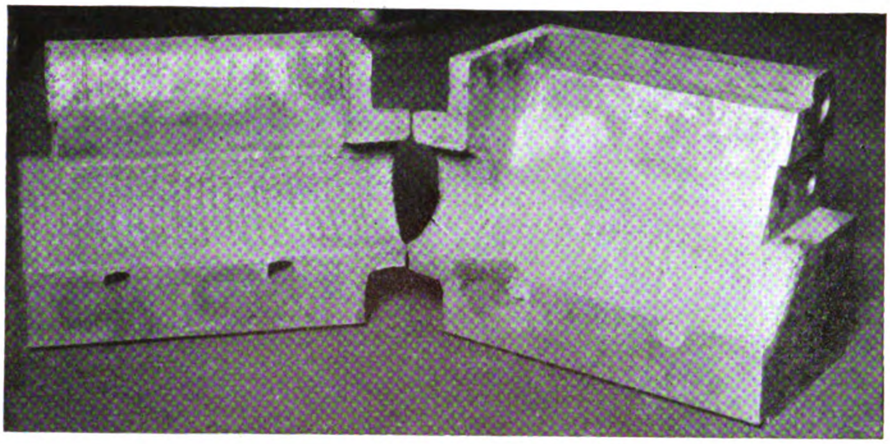
The sprocket had become badly worn before it was accidentally discovered. It was seen that failure of the sprocket might occur at any moment, which would put the draw bench completely out of service. This, in turn, would cause serious disruption of production schedules in several departments.

To replace the sprocket would have taken 10 to 15 days, if it were ordered from the manufacturer, or 4 to 5 days if it were rushed through the tool room. It was estimated that to dismantle the 12-in. shaft carrying the sprocket, press the old sprocket off and the new one on, and reassemble the machine, would take about 36 hr., at a labor cost of about $300. The cost of a new sprocket was estimated to be about $150.

It was eventually decided to remove the chain and build up the teeth on the worn sprocket by electric arc welding. This did away with the necessity of even taking the shaft out of its bearings. After welding was completed, which required 8 hr., the teeth were ground out with a portable grinder to conform to a templet.

The cost of building up the teeth by welding, including grinding to size afterward, amounted to about $20. Replacing the sprocket would have cost about $450.

The engineers in this plant point out that a broken casting loses its value, not because the material in it is worth any less than before it was



It is a simple matter to compensate for wear on this magazine for a scrap press by adding new metal with the electric arc.

This is a good example of equipment failure due to the wearing away of less than 0.5 per cent of the original weight. Arc welding makes it possible to save the original investment at comparatively low cost.

broken, but because it has no utility as a machine part. As soon as the parts are welded together again, the utility is entirely restored, as there has been no loss in the value of the material.

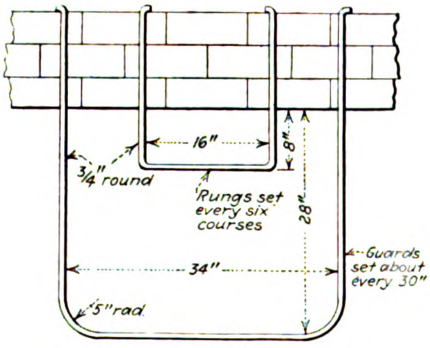
Another engineering viewpoint which has become an established policy of Timken management is illustrated in the handling of worn pieces of machinery or equipment. As a general rule, failure of equipment by wear is caused by disappearance of less than 0.5 per cent of the weight of the worn piece. With conservation of initial capital outlay in mind, it is obvious why the plant engineers are more interested in replacing the small amount of missing metal, rather than in replacing the whole part.

The great saving in time made by the use of electric welding in the operation of railroads and steamships is pretty widely known. Practically every engine house on the important railroads of the country is equipped with arc welding apparatus. Broken locomotive frames and leaking boilers are repaired in a remarkably short time. It has been said that nearly 50 per cent more locomotives would be required on the railroads of this country, if it were not for the speed with which repairs can be made with arc welding.

In conversation, several maintenance men have expressed the same opinion about the advantage of being equipped to handle emergencies with arc welding. One well-known Detroit maintenance engineer said that the "Old Man" never seemed to know he had a maintenance department until something happened to shut down an important section of the plant. In the old days before arc welding, the maintenance department was never in evidence except in some emergencies when the men could not do much to speed things up. With good arc welding equipment and with high-class operators the story is entirely different—when a breakdown occurs, the maintenance crew is on the job with the "electric needle" ready to sew up the broken parts.

Construction of Rungs and Safety Ring for Ladder on Brick Wall

IT IS common practice to erect a steel ladder on the outside of a brick wall where the height is considerable, and to put safety rings outside the steps so that a man may rest or be guarded against falling backwards in case he should slip. The strain of climbing a vertical wall is considerable and even if a man is not carrying a load he may wish to rest occasionally. Where these walls are built by specialists they usually have stock parts for constructing the ladders and rings. However, where the local Building or Maintenance Department has this work to do, such parts are not always available.



Steel rungs in ladder and safety guards which were placed on 40-ft. brick wall.

It is not necessary for the ends of the steel sections to extend entirely through the brick wall, but they should be set in at least through the second tier of brick.

The accompanying drawing shows clearly the construction of a safety ladder that was erected on the outside of a 40-ft. wall of a building into which refuse was to be exhausted. This inexpensive construction fortunately represents good practice, also.

Both the rungs and the safety rings are made from $\frac{3}{4}$-in. round stock. These pieces were cut off cold on the anvil and the ends were given a blow with a heavy hammer to put a bend at the end, as shown. This bend was of no definite amount but merely to add to the burr from the cutting off so as to make a knob that could not be pulled through the brick work.

The bend was made on a Wallace bender. The rungs or steps were given a bend of short radius. The safety rings were given a bend with a 5-in. radius, which was easy to make and which permits of ample climbing clearance. The round corners also improve the appearance. Some stack safeties are made with round or hoop rings, but these seem to restrict climbing space and interfere with a man carrying anything strapped on his back. However, it is safer to pull any tools or materials up with a rope than to try to carry them up.

When this structure was being built up, the steel parts were laid in between the joints in the brick as the courses were laid. The rungs were placed between every six courses of brick, which were approximately 15 in. apart, an easy climbing distance. The safety rings were placed 30 in. apart because it is not necessary to have them as close as the rungs.

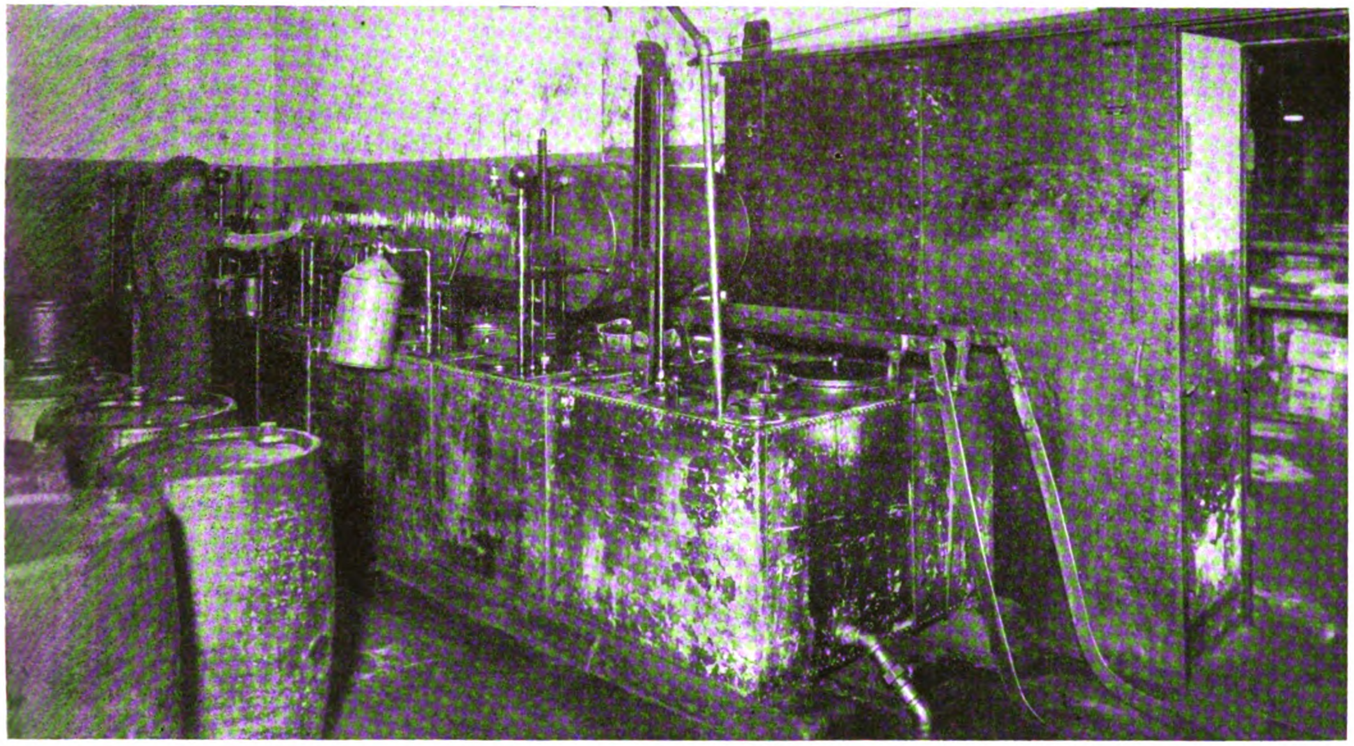
In laying the bricks, care was taken to see that each steel bar was pressed into a bed of cement mortar and that the joint was well filled around the steel. This insured a firm grip between the steel parts, to resist any tendency to pull them directly outward. In addition, the crook at the inner end of each leg gives added security against any tendency of the rungs or guards to loosen or pull out.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Methods of Storing and Handling Oil and Grease Lubricants

in Industrial Plants

By FRANK E. GOODING
Associate Editor, Industrial Engineer



Oil tank storage system in use at the Automatic Electric Company, Chicago, Ill.

In this battery of ten Bowser oil tanks, eight are of 120-gal. capacity, one 160-gal. capacity and another 230-gal. Lubricating oil, paint oils and other oils or liquids used in the plant are stored here and issued on requisition to the various departments that make use of them.

PREVIOUS articles that have appeared in this series on lubrication have discussed lubricants, their selection, devices for their application, and their use on some of the more common types of equipment. Even after all of these problems are solved there is still the necessity of providing adequate and proper storage and handling facilities. These do not always receive the attention they merit.

There are three main reasons for providing special equipment for the storage of lubricating oils—namely, prevention of loss and waste, fire hazard, and provision for measuring as issued on requisition. Although the fire hazard and loss from seepage are not as great now with the use of steel instead of wooden containers for shipping the oil, nevertheless, these two factors alone are of sufficient importance to make the cost of special storage and measuring equipment a good investment and frequently repay the cost within a period of a year or two, under ordinary conditions.

Many plant executives believe that they are saving this cost by attaching a spigot or faucet and using for storage the steel drums or casks in which the oil is received. In such a case the drums are usually laid on their side and the oil drawn out through the faucet as needed. Special pumps are sometimes used with the drums standing on end. There are several objections to this that are not fully appreciated by many plant executives. First, faucets often leak and some form of container or sawdust must always be provided to catch any drippings, which are practically a total loss.

The oil-soaked sawdust and the open oil form an important fire hazard that is always taken into consideration by the fire inspector when making his inspection upon which the insurance rate is based. Paints and several other oils and liquids that are also used in many industrial plants offer a much greater fire hazard and correspondingly affect the insurance risk to a greater extent. Storage arrangement for these liquids is frequently provided in connection with lubricating oils. However, the lubricating oil is one element of the risk and in case of fire has a special hazard, as is explained later.

Lubricating oil in containers offers very little fire hazard in itself, because it gives off practically no volatile or inflammable vapors until it is heated to or above its flash point,

which is considerably above ordinary room temperature but would be the condition in case of a fire surrounding the oil container. However, open oil will add fuel to the flame if the room should become on fire. Oil-soaked sawdust is highly hazardous.

Lubricating oil, if released in quantities in a fire, throws off heavy, suffocating fumes that force the firemen out of the building and so increases the difficulty of fighting the fire. For example, a recent fire in a Mid-Western industrial plant was almost under control until the heat burst open or melted the faucets on two drums of lubricating oil. In this fire one man lost his life due to the fumes and the firemen were forced so far from the source of the flames that the plant was practically a total loss.

It is stated that the special lubricating oil tanks, such as are manufactured by several concerns and are shown in some of the accompanying illustrations and described in more detail later, are provided with vents that permit the vapors to escape more slowly, in case the fire surrounds the tank, and to burn without causing heavy fumes such as result when the oil floods the room when a cask or drum is burst open.

Comparatively few plant executives have any real appreciation of the amount of loss through leakage. The amount of oil from even a faucet that is dripping slowly, either because of a leak or because it has not been shut off completely, will be considerable in a comparatively short time, as is shown in the accompanying combination chart and table on page 110. For example, a leak of only one drop per second would amount to 1⅛ gal. in 24 hr. Many times even more heavy dripping from partly closed faucets goes on undisturbed over night and often over the week end as well. Usually the first man to find the wasted oil cleans it up as well and and as quickly as he can and the management never learns why the drum was used up so quickly.

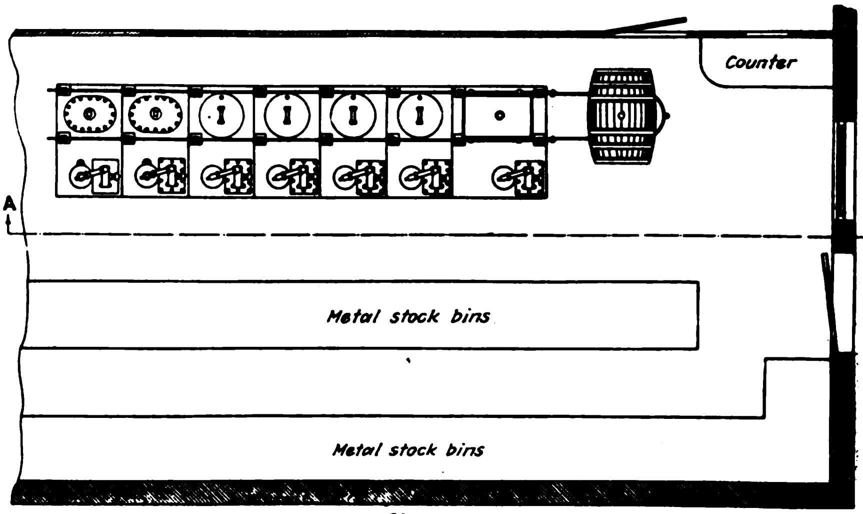
The representative of an oil company stated that it was not at all uncommon to find from ½ gal. to 5 gal. of oil remaining in the barrels when they are returned to the oil company. The drums are always emptied and cleaned before being used again, and so this oil remaining in them is a total loss. However, it has been paid for and this extra expense adds to the cost of lubrication in the plant.

Probably one of the most extensive and expensive practices in oil storage is to leave the oil and other liquid storage rooms open on a "help-yourself" basis. This is true whether the oils are stored in the original containers or in special tanks. When any material is left open in the storeroom for general consumption whenever the different men or departments in the plant want it, there is always a tendency to belittle its value, because men are not inclined to be careful with material which they do not consider as having much value or upon which the management does not put its real value. Also, there is an inclination to take as much as they can at a time, and if they do not have any proper place or container in which to keep the surplus lubricant, it is likely to be lost or to get dirty. In either case it is wasted. However, if the dirty oil is used, it may cause bearing trouble. Comparatively few industries have a dust-free atmosphere, where open oil would not become contaminated within a short time so that its use in bearings might be disastrous.

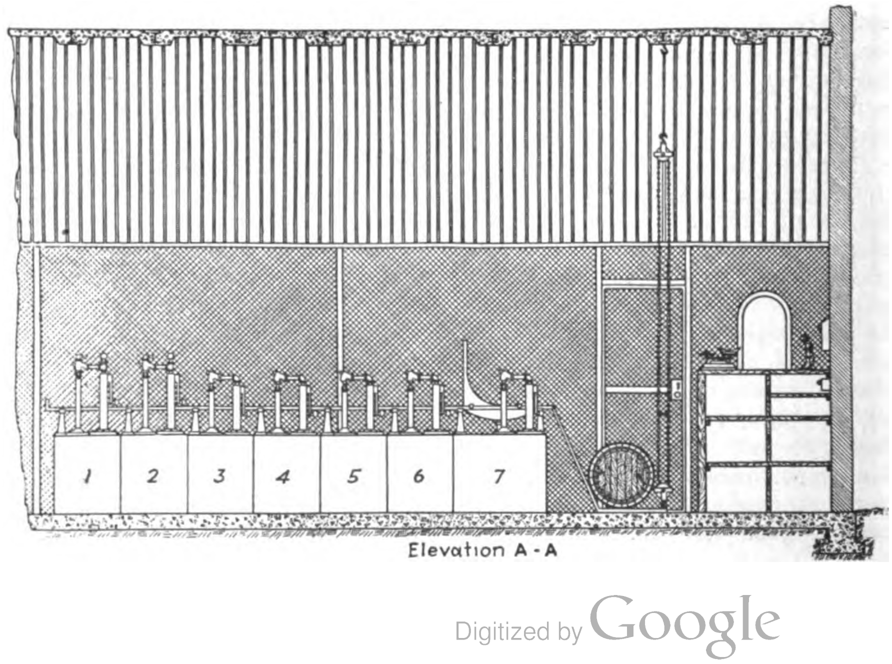
In plants where the oil storage is open to anyone in the shop the men are likely to congregate when going after the oil. When the oil is drawn through a faucet, they may not watch it close enough and so overfill the container and add to the loss and waste. If men come in by themselves, there is a danger that they may try to "steal" a smoke while waiting. This adds to the hazard because of sawdust as well as the other and more inflammable oils that are usually stored in the same location.

Heavy oils run very slowly during the winter, particularly in unheated oil houses. When a man comes in to get oil and knows that he will have to wait for some time while his measure is filling, he is likely to visit in a neighboring department where it is warmer. It frequently happens that he either forgets the oil entirely or else does not time his visit properly and upon his return finds that the measure has overflowed. A

A common method of arrangement of oil storage in the stock room.



Plan



Elevation A-A

shovelful of sawdust will quickly cover up the mistake.

Another disadvantage of using the drums or casks as containers is that it is rather difficult to know how much oil is left in them. If the quantity on hand is not known or is not quickly ascertainable, there is great likelihood of running out of a supply of oil.

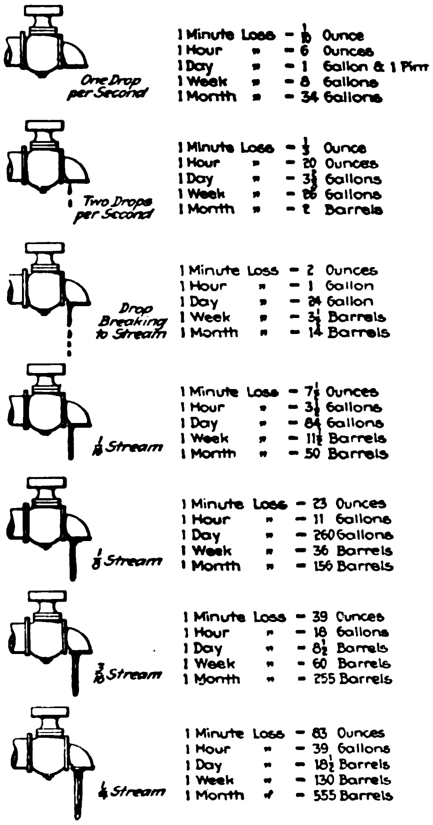
Many industrial concerns that have investigated their oil-storage problem and evaluated the wastes have discovered that poor methods of handling are expensive. A number of types of storage equipment are on the market and also different methods of storage are used to serve particular purposes and meet special conditions. The various types of equipment available are, in general, quite similar. In practically all cases they consist of a square or rectangular steel tank, with riveted and soldered or welded joints. A type of tank that will hold 2 bbl. of lubricant will occupy little more floor space than a barrel; with some types of equipment the width of the tank is less than the diameter of the barrel. This gives a space-saving advantage, as well as an increased storage capacity, which is especially valuable where space is at a premium.

With adequate storage tanks the casks or drums can be emptied practically as soon as they are received and the empty containers returned at once, so that the plant does not have to give them storage. This is an advantage, however, of which comparatively few concerns make full use, with the result that in many cases the empty containers are retained indefinitely and occupy considerable valuable space. A number of empty barrels standing around does not improve plant housekeeping.

Practically all of these storage tanks are provided with a measured discharge whereby each turn of the crank delivers a definite amount of oil. The quantities delivered vary somewhat with the different tanks. The particular advantage of the measuring feature of these storage tanks is that when oil is issued on requisition a more careful check can be made of the quantities given to each individual.

Many plants that have a carefully worked out requisition system for practically all other materials issued from stock have, for some reason or other, not placed the oils, either those used for lubricating purposes or other liquids used in plant production or processes, under anywhere near as careful checking system. This is attributed to some extent to the belief that the oil cannot be used anywhere else than in the plant.

The ordinary oil containers used around the shop are not very accurate in their rated measurements and if filled for 1 gal. or 5 gal., whatever they are supposed to hold, the actual amount may be either consid-



This shows what the loss from leaking faucets will amount to.

The oil wasted is not the only loss, because there is a fire hazard created that is usually taken into consideration in establishing the insurance rate.

erably over or under. The only way to check on this is to measure the liquid as it is taken from the tank. With a requisition routine, an assurance that the proper quantities that are called for are issued, and a cost system, it is always possible to know how much lubricants actually cost, and no industrial activity can be controlled unless its costs are known and analyzed. Where this is done, it is possible to compare the value of different lubricants and base the decision as to which is the best on actual facts instead of on a guess.

Tank storage with pumps also save considerable time, because the lubricants can be drawn from the tanks much more quickly than if it is necessary to wait for them to flow, particularly in cold weather. Also the requisition can be filled by means of a pump while a man is waiting without his wasting an excessive amount of time. In addition, there is no spillage and any drip runs back either into the tank or into a waste. In this way it is not necessary to use sawdust on the floor, which immediately takes away an important fire hazard. This also permits and encourages better housekeeping.

These tanks or containers are usually placed in multiple or in batteries of a number of compartments or tanks of the most advantageous sizes to store the different materials handled. Several of these storage units are illustrated here. The illustration at the head of the article, for example, indicates the arrangement at the Automatic Electric Company, Chicago, Ill. In this case all of the oils or other volatile or semi-volatile liquids used in the plant are stored in this battery of oil tanks. The first tank at the right is a 230-gal. container, holding a special thinner. This has special provision for agitatting and circulating the liquid and is also vent-proof so that none of it will evaporate. The next is a 160-gal. cutting-oil tank. The remainder of the tanks are all of 120-gal. capacity. The tanks, beginning with the third, contain the following liquids: lubricating oil for shafts and machinery, dynamo oil for motors, another cutting oil, linseed oil, alcohol, lard oil, paraffin oil, a tank temporarily not in use, and turpentine. In cases where the liquid is very volatile the tanks are not vented and are evaporation proof. This is particularly necessary in the storage of paint and linseed oil.

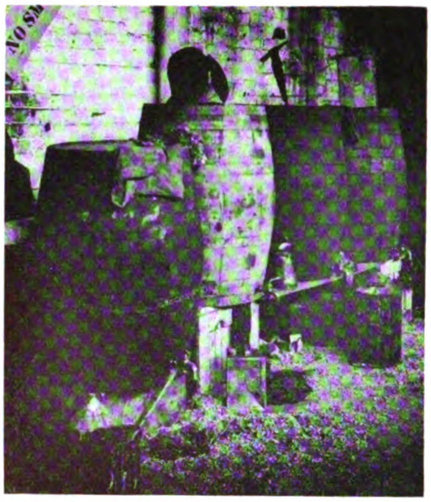
This installation has been in use for a number of years and, according to those in charge of it, the elimination of the necessity of using sawdust on the floor was one of the important advantages resulting from the change; this not only improved the plant housekeeping but also reduced the fire hazard. Other noticeable results are the elimination of any argument as to whether a department is getting the amount of oil for which it is charged and the ease with which the inventory record and the quantity of oil on hand can be checked. A gage on each tank enables the storekeeper to read the number of gallons remaining in the tank at any time.

The drums or barrels of oil are rolled onto the skid at the right and lifted by a chain hoist which, because of the limited space, is suspended directly in front of the doorway and

so must be removed when not in use. It is usually possible to empty several barrels at a time and so make it unnecessary to place this hoist in position often. The barrel is rolled on the barrel track to the proper tank, the inlet opened, and the tap in the barrel removed. The oil flows down into the tank and the barrel is permitted to drain until empty. The measure on the tank may be used to check the accuracy of the invoice with the amount of oil that was contained in the barrel. However, at the plant of the Automatic Electric Company this is checked by weight. Each barrel of oil received is also tested to see that it comes up to the contract specifications under which it is purchased.

There are objections to purchasing lubricating oil from a variety of sources. One of the most important of these, however, is not often appreciated. For example, it is not always desirable to mix two different blends or types of oil. For this reason, whenever a new source of supply is obtained, or a different brand of oil is to be stored in the tank, it is always well to clean the tank out thoroughly first. It requires very careful tests to be sure that the new oil is of the same quality and will be as good as that which had been purchased previously. Two oils may look alike, "feel" alike and, in a large measure, test similarly in certain of their characteristics and qualities, nevertheless they may be made from entirely different petroleum sources and not give the same lubrication service on a bearing.

There is another point that sometimes must be taken into account in the installation of these tanks. This is best illustrated by the experience of the representative of one oil concern. The customer complained of water and mud in the oil when drawn from the tank. A check-up on several barrels of oil as received found no trace of water. The representative investigated, however, and he learned that the tanks had been stored out of doors for several days before they were placed in position inside the building. A check-up of

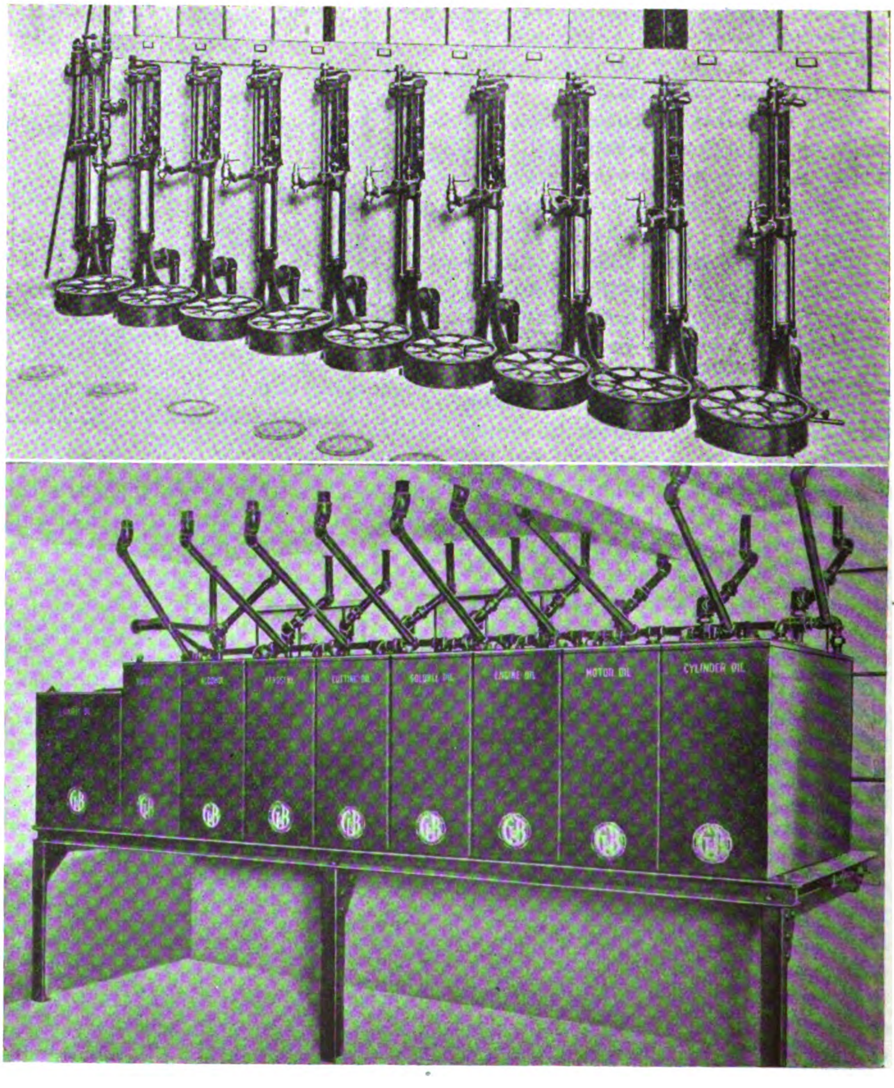


Happily, storage conditions such as this for lubricating and paint oils are rapidly disappearing in industrial plants.

the other tanks that had been installed at the same time showed that several others contained water and mud also. Those in charge of the plant then remembered that it had rained while these tanks were outdoors and that they had not been cleaned and emptied before installing. The danger of this is greater in connection with underground tanks, which sometimes lie around for a week or more before they are buried.

Underground storage is used for either or both of two reasons. Such a procedure is required in a number of the larger cities and by many fire insurance companies in connection with the more inflammable oils such as naphtha, linseed oil, turpentine, benzine, and so on. This is not often required of the lubricating oils, but it is sometimes desirable when they are bought in carload lots and stored in quantities, because then the tanks can be located out of the way more conveniently than if placed above ground. Also, the tank car can be drained by gravity. Carload purchases and deliveries have a price and freight differential that will help pay for the installation provided a sufficient quantity is used to make such an investment worth while.

The most common reason for using underground storage tanks is



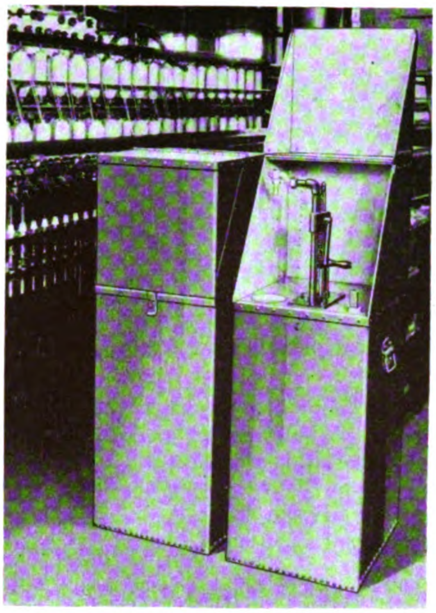
Frequently space considerations do not permit placing the tanks in the storage room.

In such cases, the outlet pumps may be located one or more floors away from the tank, which is either placed in the basement or, with the more inflammable liquids, placed outside. This is a Gilbert & Barker battery storage installation on the first floor and basement of the Bethlehem Foundry & Machine Company.

lack of space inside the building. Frequently, however, these tanks are placed in the basement. This conserves floor space because, if necessary, a sub-basement can be excavated to hold the tanks. Also, much less floor space is required than when the tanks are placed on the floor instead of underneath the floor or in the ground.

It is possible, by using power-driven pumps, to place the outlets of these tanks at various locations in the building, even often several hundred feet away. This is not so commonly done with lubricating oils as with some of the other oils that are used quite generally in the plant.

When deciding upon the type of storage installation or method of control of the lubricant, the question often arises whether to have one central distributing point or a central distributing and receiving store with several branch distribution stores. The answer to this question should always be based upon the conditions surrounding the plant and the operation involved.



Lubricating oil is always convenient in this textile mill, but cannot get dirty.

Instead of providing a main central storage and issuing oils to the various departments in small quantities, a small, totally inclosed Bowser tank is placed in the department. The oiler can go directly to the tank and fill his oil can whenever necessary. The cover can be closed down and locked, if desired.

To cite an example, a Mid-Western steel mill originally installed a central oil storage and issued all oils on daily requisition. Plans are now under way to change this somewhat so that, although the oil is all received and issued from the central storeroom, a number of sub-storerooms are placed at carefully selected points in the plant. Oil is still to be received in carload lots, but is not to be sent to the sub-storerooms in less than barrel lots. The auxiliary storeroom, in turn, issues the oil in smaller quantities as required. Each of these smaller auxiliary storerooms has its battery of oil tanks and pumps.

In other plants it has been found desirable to place pump outlets at each floor and have a single storage tank in the basement feeding to all of the separate outlets. However, in any of these cases the storage should not be open on a "help-yourself" basis, except possibly where only one or two men have access to it. Even then this man or men should keep a record of what is used. Where kept in Stores Departments the oil should be issued on requisition only and by or under the direction of authorized representatives of the Stores or Maintenance Departments.

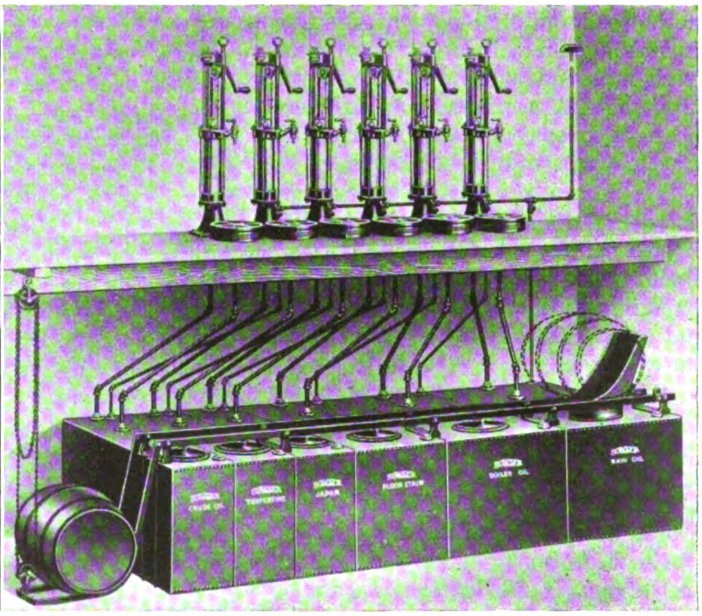
At the East Pittsburgh plant of the Westinghouse Electric & Manufacturing Company the lubricating and other oils are handled from a central oil house. On an average about 5,000 gal. per month of one type of lubricating oil is used. This is ordered in tank-car lots and a storage capacity of 8,500 gal. is provided. There are three outlets for the distribution of this material to the various departments: One is on the first floor of the oil house above the storage tanks; the two others are the outlets of pipe-line connections that are placed approximately half a mile from the central oil house to give more central location for distribution to the various shops. Material is delivered by motor trucks from the most convenient of these three

The method of handling grease in one plant.

This special grease pump and drum truck are used for oil and grease storage at the Bassick Manufacturing Company, Chicago, Ill. The operator is filling the portable filler tank, which is carried on into the shop and used for filling the Zerk pressure grease gun.

This shows the saving in space made possible through placing the tanks in the basement and the outlets on floors above.

This Bowser installation consists of a battery of six tanks and pumps. The method of emptying the barrels is well shown. Tanks of various capacities are used to fit the storage requirements and correspond with the amount of liquid handled. The mistake is sometimes made in not ventilating or keeping the basement or vault in which the storage tanks are placed clean and dry.



oil stations to the proper departments.

The department ordering lubricants issues a works requisition on the Stores Department, specifying the quantity and grade of material desired. After this requisition is filled it is then forwarded to the office to go through the regular cost routine.

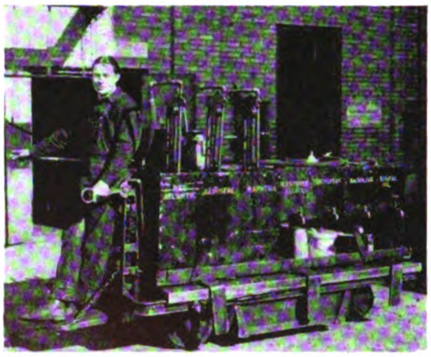
The savings made possible by using a comprehensive system for handling, storing, and issuing oils and greases were well shown in an article entitled "How $6,929.06 Has Been Saved in the Purchase, Storage and Distribution of Lubricants," which appeared in the October, 1924, issue of INDUSTRIAL ENGINEER. This described the practice followed at the Allis-Chalmers plant in Milwaukee. The saving during the first year came within $461.42 of paying the entire cost of the new installation.

Briefly, the system followed at this plant is to have a central receiving and storing oil house with a battery of fifteen 120-gal. Milwaukee Tank Works tanks equipped with 1-gal. pump and hose connections. In addition, there are three underground tanks for the oils that are received in carload lots.

Instead of issuing all materials direct to the various departments from this central storeroom, 22 sub-storerooms are located about the plant. An electric truck that carries Milwaukee compartment tanks, as shown in an accompanying illustration, makes these deliveries daily in 2½ hr. Each oil, liquid, or grease is issued in various standard-sized units and no man is supposed to be given more than a day's supply. This method of handling lubricants insures that each man will have a supply of fresh material at all times, and yet cuts waste to a minimum. Furthermore, it is easy to keep a check on the consumption of lubricants.

The general practice as to who has charge of oil storage varies in different plants. A large number of plants place the storage under the direction of the General Storekeeper and handle it the same as any other material.

In a considerable number of other plants, particularly those in which the maintenance is of considerable importance, it is frequently the practice to have a special Maintenance Store, under the direct supervision of the Maintenance Department. In such cases, if lubrication is handled by this department, the storage of lubricating oil should go in the department. One of the big advantages of the separate Maintenance Store is that the Maintenance Department has access to it on Sundays, nights, and at other times when the remainder of the plant and general storeroom are not open.



Oils, greases and other similar supplies are distributed from the central storage to the 22 departmental stores on this electric truck.

This installation shows the method used at the Allis-Chalmers Manufacturing Company's plant in Milwaukee, Wis. Two Milwaukee tanks with compartments of suitable size are placed on the truck for this delivery. Previously 55 men made a trip to the central oil house daily. Now one man with the truck makes the deliveries in 2½ hr. This has resulted in an important saving of time.

Grease lubricants offer a somewhat different handling problem than do the more liquid oil lubricants. For example, grease is seldom taken out of the container in which it is received until it is to be used or at least ready to be issued to the man who is to use it. One of the most important things to consider in contion with the storage of grease lubricants is to see that the covers are kept closed on the containers so that grit and dust will not get into the lubricant and make it unfit for its intended purpose.

The main oil house of the Allis-Chalmers Manufacturing Company.

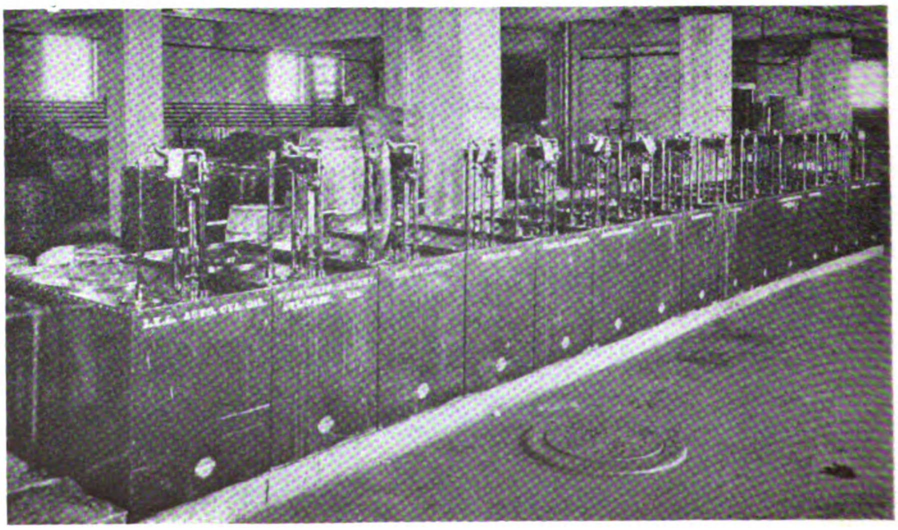
Here fifteen 120-gal. Milwaukee tanks are used in the central storage of lubricants and other oils. The storage truck is loaded up here and makes the deliveries to the various sub-departmental stores. In addition, large underground tanks are used for liquids handled in large quantities. This permits buying in carload lots, which makes a saving of about 5 cents per gallon.

Grease should be handled on requisition from the same stores and by the same routine used with issuing oil. It is seldom desirable to handle and store grease lubricants in the factory proper, because of the increased amount of dust in the atmosphere and the greater likelihood of its getting into the grease whenever the container is open. One of the accompanying illustrations shows the method recommended by the Bassick Manufacturing Company for the handling of grease when it is purchased in drum lots.

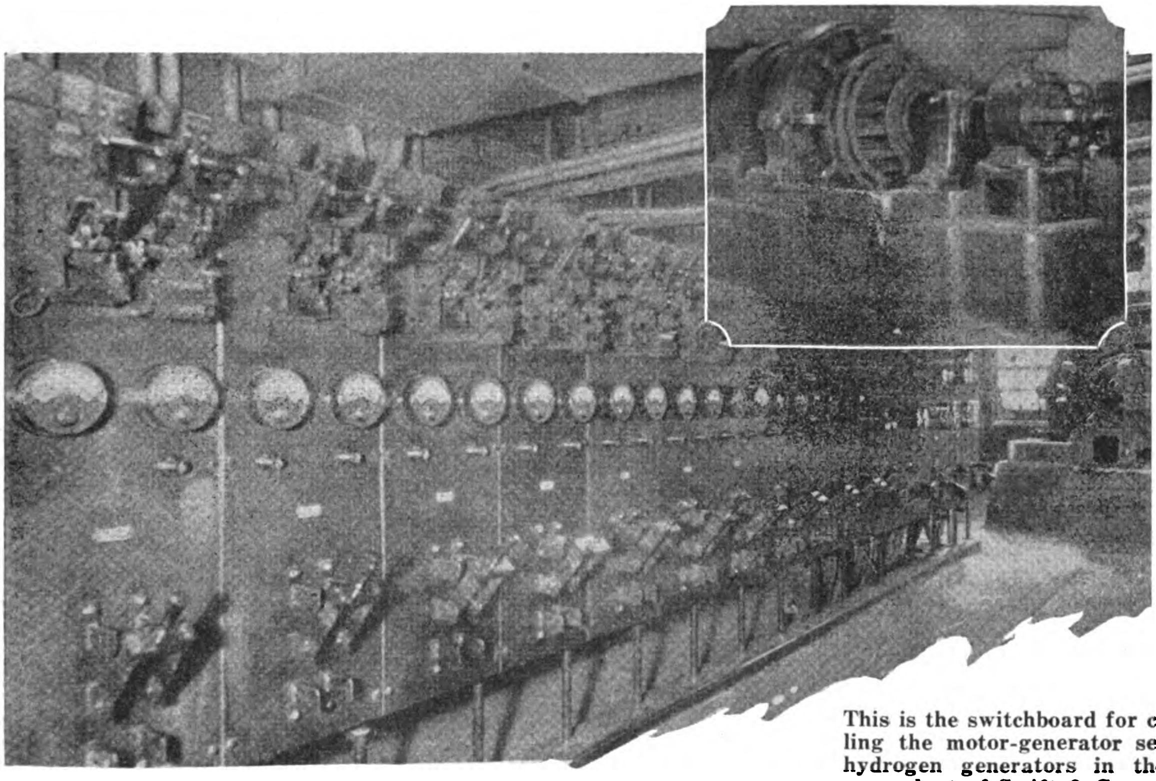
This outfit consists of a truck and a special pump for removing the grease and filling the smaller portable container that is taken around the plant by the oiler and used to refill the pressure gun. Another method of handling grease is to use, instead of the small handgun, an extra-large pressure device that has a chamber holding a large quantity of grease and so requires comparatively few refillings. The operating convenience should be taken into consideration very carefully whenever deciding upon any type of such equipment.

EDITOR'S NOTE—Acknowledgment is given to the following companies for supplying illustrations and information in connection with this article:

Bassick Manufacturing Company, Chicago, Ill.; Bennett Pumps Corporation, Muskegon, Mich.; S. F. Bowser & Company, Inc., Fort Wayne, Ind.; Gilbert & Barker Manufacturing Company, Springfield, Ohio; Milwaukee Tanks Works, Milwaukee, Wis.



Midwest Engineers Discuss Power Problems That Confront Industry



This is the switchboard for controlling the motor-generator sets and hydrogen generators in the Chicago plant of Swift & Co.

There are two of these motor-generator sets, one of which is shown in the insert, which are rated at 700 kw., and are driven by 2,200-volt synchronous motors. They supply direct current at 120 volts, for the production of hydrogen which is used in solidifying vegetable oils in the manufacture of shortenings and other products.

THE second annual Midwest Power Conference was held in connection with the Midwestern Engineering and Power Exposition, or Chicago Power Show, at the Coliseum, Chicago, Ill., Feb. 15 to 19, inclusive. This conference was sponsored by the local sections, regional and professional divisions, of the American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, National Electrical Light Association, Western Society of Engineers, and National Safety Council.

At the Power Show 260 of the leading manufacturers demonstrated the latest equipment and practices in connection with power generation, distribution and utilization. This was a considerable increase over the number of manufacturers, 175, who had exhibits at the Power Show a year ago.

On the second day of the conference power problems in various industries were discussed from the standpoints of generation and utilization. In the following abstracts of these discussions, those portions of the papers dealing with the generation of power have been omitted, except where this is almost inseparably linked with the application. Likewise, the problems involved in the utilization of heat, which is so closely connected with some of the industries discussed, are merely touched on in these abstracts, although in some cases this subject was treated quite fully in connection with the problems incidental to the generation of power.

The subjects selected for this discussion are those which are very closely tied up with the industrial developments of the Middle West: steel mills, food industry (corn products), paper and cement mills, and the packing industry. It is quite fitting that the industrial men in the Middle West should have this opportunity to see the latest developments in equipment for the generation and utilization of power, and exchange their experiences through the medium of the papers and discussions that were presented.

It is stated that the immediate Chicago region has the greatest per capita utilization of electrical energy of any section of the world—1,050 kw.-hr. per capita per year.

The central district contains the greatest transmission interconnection system under one interest of any place in the world and the largest generating station in the country is in the making.

The formal program of papers and discussions was supplemented by inspection trips to various public utilities and industrial plants.

Power in the Packing Industry

By C. H. KANE

Manager, Construction Department, Swift & Co., Chicago, Ill.

SYSTEMS involving the generation of power in the packing industry are confronted with the great difficulty of bringing the requirements of steam for processing and heating, which are necessary about 8 hr. a day, in balance with the power requirements of refrigerating machines, pumps and a portion of the manufacturing load that is required over the 24 hr. It has been found that the balance is in favor of using central station service for power requirements, where satisfactory service and price schedules are available, and generating steam at low pressures for processing, instead of trying to generate all the power.

In 1915 our Chicago plant tried out central station service to the extent of about 2,500 kw. demand. Our load has now increased to 10,000 kw. demand and the load factor has increased from about 40 per cent to about 65 per cent. Central station service has been profitable, economical, and extremely convenient.

Electrification of our present refrigerating machines will be considerably hastened by the development by electrical manufacturers of slow-speed synchronous motors, reasonable in cost, from 55 hp. to 1,200 hp. rating, operating at a speed of about 60 r.p.m. We have about 5,000 hp. load of this character in Chicago, and similar loads on a smaller scale in all of our large plants. We have installed a number of medium-speed refrigerating machines developing from 400 to 500 tons of refrigeration per unit and mounted a synchronous motor on the shaft. By dropping the connecting rods and the valve gear rods on the cross-compound engine, the synchronous motors can be used to drive the compressors very satisfactorily. During the winter months we connect up the rods and the valve gear on the steam engine and use the exhaust steam. Either prime mover takes the load in case of accident. This procedure, however, represents a heavy initial investment which is justified only where a low power rate is available.

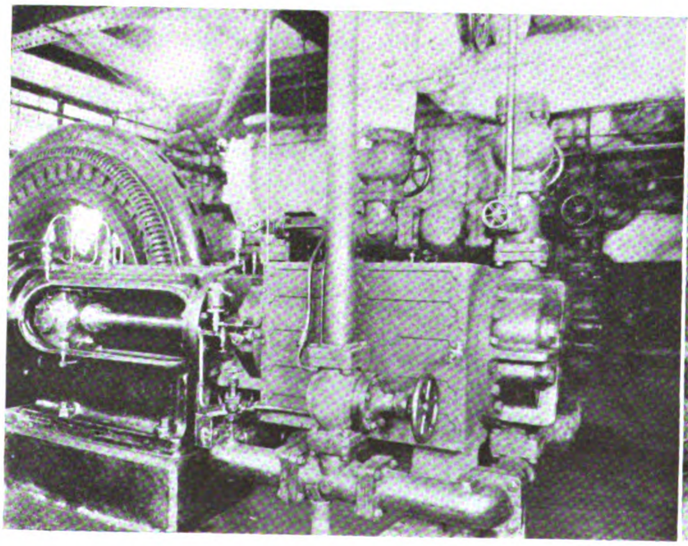
I believe that the meat packing plant of the present and the future will ultimately operate every power-driven piece of machinery, whether it be for mechanical purposes, or for pumping, mechanical refrigeration, intraplant transportation, electric lighting and certain forms of heating, from central station service.

Manufacturing power will be understood to include the power used from the time the stock is received on the hoof at the packing plant until it is slaughtered, dressed, refrigerated, loaded into cars or trucks, and sent away to the consuming public, as well as that consumed in working up the byproducts and the inedible products. Animals, through the killing and dressing operations and into the refrigerating rooms, are lifted with motor-driven hoists and carried on motor-driven dressing chains. Byproducts are processed by motor-driven equipment. The Sausage Department, for example, uses a large amount of power for grinders, food choppers and stuffers. The Lard Refinery uses power for operating lard chilling rolls, pumping, conveying and other machines. The motors driving these various machines range in size from 1 hp. to 150 hp. and for the most part operate at constant speed, although in some cases variable speed is used.

In the Chicago plant the total horsepower represented by refrigerating, pumping, electrical drives for manufacturing, and so on, will aggregate about 30,000 hp. which is divided as follows:

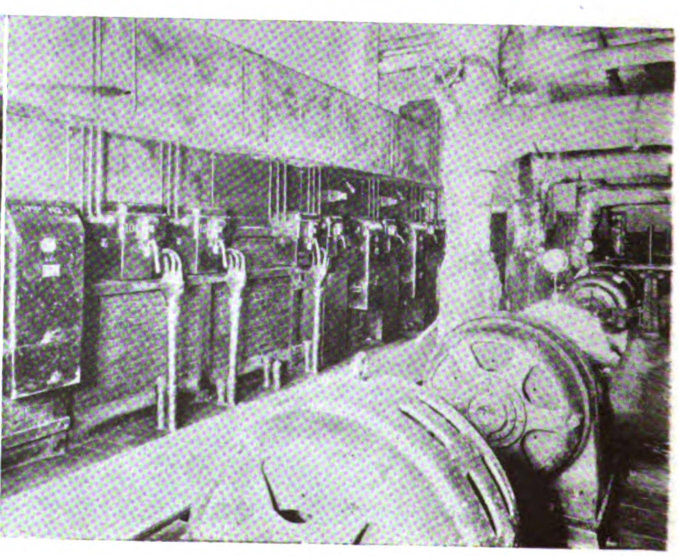
- Steam-driven refrigerating machines about 8,000 hp.
- Combined steam-driven and electrically-driven pumping equipment about 5,000 hp.
- Electric power used for manufacturing, produced by our own power plant about 3,000 hp.
- Electric power used for manufacturing, supplied by central station service about 12,000 hp.

The electric power generating station is equipped to generate about 6,000 kw. and our agreement with the central station provides that we will operate during their peak period with our station as a part of their stand-by power; during the fall and winter months we operate in parallel with their service. In December we



Here a standard, medium-speed, refrigerating machine is driven directly by a synchronous motor mounted on the shaft.

The flywheel is entirely eliminated and the flywheel effect is provided by the rotor of the motor. This is a very compact unit requiring only 588 sq.ft. of floor space and develops 400 to 500 tons of refrigerating capacity.



Part of a battery of nine motor-driven brine pumps.

Each of these pumps has a capacity of 2,000 gal. per min., and is driven by a 200-hp. squirrel-cage motor. This is a very desirable load for central service and with a constant-speed motor and constant head, the power factor will average about 93 per cent. A similar installation of pumps supplies the Chicago plant with 10,000,000 gal. of water per day.

operated on peaks with our power plant over a period of 2 hr. per day for several days during the month. The total power sold to the central station for the month amounted to 25,000 kw.-hr.; during this same period we purchased a total of 3,000,000 kw.-hr.

To supply our Chicago plant with water requires an installation of pumps with a capacity of some 10,000,000 g.p.d., equivalent to the consumption of a city with upwards of fifty thousand people.

Vertical, motor-driven turbine pumps are used in wells ranging in depths to 250 ft. Drilled wells from 600 to 2,000 or 3,000 ft. in depth are operated by the air-lift system. Two-stage compressors connected to medium-speed synchronous motors supply the air.

Direct current for the electrolytic dissociation of water to produce the hydrogen used in the solidification of vegetable oils in the manufacture of shortenings is obtained from two 750-kw., 120-volt generators, each driven by 2,200-volt synchronous motors operating at 100 per cent power factor and 100 per cent load factor.

For intraplant transportation, the electric tractor equipped with storage batteries is rapidly and economically replacing hand trucking and teaming. In the operation of 50 tractors in our Chicago plant, a charging station that will simultaneously accommodate 40 tractors is provided so that the charging can be entirely done off-peak. Each tractor will operate over a period of 8 hr. continuously without recharging and will consume a total of 1,500 kw. on the average run of 10 hr. per day.

These tractors, when operating for long and short hauls, and on grades not exceeding 5 per cent, will handle easily four trailers or a total of 6,000 lb. at a speed of 6 m.p.h. Special elevators with platforms 6x45 ft. designed to accommodate the entire tractor train without uncoupling the trailers are used in our Chicago plant.

Use of Power in Steel Mills

By WILFRED SYKES

Assistant to General Superintendent, Inland Steel Company, Indiana Harbor, Ind.

PROBABLY the most important item in the development of the industry has been the ready availability of power, which can be substituted for human effort. The increasing growth of the steel industry has paralleled the growth of the power industry. With each great improvement in the development and distribution of power, and the facility with which power can be applied to mechanical devices, there has been a corresponding increase in the production of the industry, coupled with an improvement in the working conditions and the standard of living of those employed in it. This has also been usually accompanied by a reduction in the cost and selling price of the product. Figures from one plant indicate an increase in production per man of about 35 per cent within the past 10 yr., in spite of the elimination of the 12-hr. day. European plants, which are not so completely equipped with labor-saving devices, have a production per man of only about 40 per cent of what we obtain.

At the present time the steel industry is largely electrified. About 35 yr. ago, the first efforts were made to use electric motors. The electric motor made the modern traveling crane possible, and this was the first main application of motors in the steel mills.

In the early days power was developed in the mills by direct-current generators driven by reciprocating engines. The units were usually small and frequently scattered in groups over the plant, so as to limit the distance power had to be transmitted. Later the practice changed to the use of alternating-current generation and distribution with converting arrangements to provide direct current where needed. In general, it has been found that for a large proportion of auxiliaries, direct-current motors have more desirable characteristics than alternating-current machines.

It is estimated that the total amount of power used in the industry in 1926 was equivalent to about 7,000,000,000 kw.-hr. Approximately 75 per cent of the power was generated in the mills and about 25 per cent was supplied from outside sources, largely from central station plants. The approximate rating of motors used in steel mills is 3,500,000 hp., of which over 1,000,000 hp. are driven by purchased power.

The power required for driving rolling mills varies with the type of mill and its product. The largest units are used with the reversing mills, the motor driving the rolls developing momentary outputs of 10,000 to 15,000 hp., with an average load of 6,000 to 7,000 hp. For driving other mills the peak loads are not so high, but the average load may be in the same order. The largest continuously-rated motor installed at present for driving a mill is 9,000 hp., but frequently several motors are used to drive different units of a single mill and the total may be much higher. The service of reversing motors is probably the hardest work performed by electric motors on any application. It is interesting to note in this connection that not only has the motor successfully performed this severe duty, but it has enabled greater production to be obtained at lower cost.

Many of the continuously running mills are driven by constant-speed motors, but there is an increasing use of adjustable-speed motors to enable mills to be run at the best speed for the particular product being rolled. With constant-speed motors the speed of the mill is usually a compromise between that required for the lightest and heaviest sections. Adjustable-speed drives allow of better production in many cases. As alternating current is practically universally used for power purposes various schemes have been evolved to obtain adjustable-speed drives, all, however, involving undesirable complications. There has, therefore, been a tendency in recent practice to use direct-current motors with either rotary converters or motor-generator sets to convert to direct current at the mill. Such drives are not quite so efficient as the various alternating-current combinations, but have the advantage of simplicity.

For a great many auxiliaries, where the service requires frequent starting or reversal, especially sturdy motors have been developed. Many applications in steel mills can be taken care of with ordinary commercial machines, but most of the auxiliary drives around the mills proper have special mill-type motors. These auxiliary drives usually do not exceed 100 to 150 hp. in single machines. The amount of power used for auxiliary purposes in steel mills is a very large proportion of the total, frequently amounting to one-third or more.

Power in the Cement Mill

By J. H. LENDI

Chief Electrical Engineer,
Universal Portland Cement Company,
Chicago, Ill.

A CEMENT mill, when considered as a power load, is unique among industrial plants in that it operates at an exceptionally high load factor over a 24-hr. day. Any departure from 100 per cent daily load factor is caused by incidental operating difficulties and not by essential interruptions in the process. Moreover, this condition persists over weeks and months except as influenced by holidays.

In a year's operation the load factor is lowered because of a seasonal variation of demand for cement. An annual load factor of 75 per cent is usually obtained, against a monthly factor of 80 per cent, which is about the highest that may be expected.

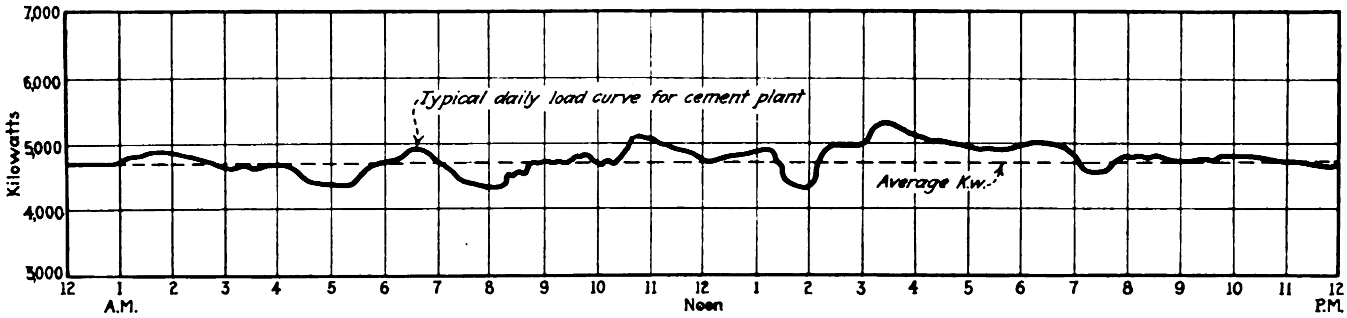
Not only is the rate of use of energy uniform, but also the consumption of energy is large, as may be realized when we consider that during the year 1926 the cement industry of the United States consumed more than 1,500,000,000 kw.-hr., the equivalent of about 2½ per cent of the electric energy generated by all light and power utilities. As an example of this remarkable load condition the accompanying chart gives a typical daily load diagram taken from actual operations, which indicates a load factor of 89 per cent.

The load factor over the year as measured by the two highest average daily kilowatt demands against the average kilowatt load over the year is, in this case, over 71 per cent. A load of this sort at 80 per cent power factor is, therefore, very desirable from the standpoint of the power sellers. Unfortunately for them, however, the cement mill has the ability to furnish its own power practically as a byproduct of operation, due to the waste heat of the cement kilns.

The manufacture of cement consists, briefly, of grinding and mixing of the raw materials, burning them in a kiln, and the grinding of the finished product. Coincident with the preparation of the raw materials coal is also powdered for drying and burning these raw materials.

To make the final product, cement, it is again necessary to repeat the grinding operations on the clinker after burning, which requires the expenditure of 7 kw.-hr. per barrel of cement in addition to the 10 kw.-hr. which have been already used, including all incidental power uses before the raw material becomes clinker, thus making a total of 17 kw.-hr. per barrel of cement. The process of burning is essentially continuous and, therefore, requires continuous preparation of raw material and also the final grinding of the finished product. This is the reason for the high load factor found in cement mills.

It would be desirable to be connected with another power system that could take the excess of power generated and serve as a source of supply when momentary shortages occur. Results have been published concerning other installations, which put the upper limit of cost of power generated from byproduct heat at 0.75 cents. It is indeed a poor installation or operation that cannot equal this. If power were to be purchased, it would necessarily have to be as low as this cost of byproduct production.



Curve indicating the practically constant daily power demand in a cement mill.

Use of Power in Paper Mills

By V. D. SIMONS

Consulting Engineer, Chicago, Ill.

NEWSPRINT and other papers made principally of mechanical pulp or "ground wood" require energy so out of proportion to heat that they cannot be made in a competitive market without the use of cheap hydroelectric power. From pulpwood to finished paper requires about 1,700 kw-hr. per ton of paper and only about 10,000 lb. of steam—an impossible water rate for steam-electric generation.

Book paper and paper board mills where exhaust steam is usable to cook out ink, sizing, and dirt from old paper stock, can be operated on 550 kw.-hr. and 12,500 lb. of steam per ton of product. Book paper mills in conjunction with soda pulp mills, where exhaust steam is usable to prepare the cooking liquid and for evaporation, require about 635 kw.-hr. and 15,400 lb. of steam generated at 400 lb. gage pressure and 650 deg. F. to produce a ton of paper. Paper or board mills located in a city often find it advisable to generate the direct current for driving the paper machine with a non-condensing, direct-current turbo-generator and purchase the requisite alternating current for other motor drives.

Theoretical balance of demands for heat and mechanical power over a 24-hr. interval must take into account those periods when electric power is at a peak and the exhaust steam requirement is low, and *vice versa*. The balancing of heat and power demand is, perhaps, the most vital problem to be solved by the paper mill engineer.

As stated, the energy requirement of newsprint production, commencing with cordwood, is far greater than for any other variety of paper. The requirement for grinding the wood is 1,300 kw.-hr. of the total 1,700 kw.-hr. per ton of product. The en-

ergy loads of other paper mills are nominal, amounting to about 200 kw.-hr. per ton of paper for the beater room, which is the largest departmental load.

There is a reasonable hope that the characteristic load of all paper mills will be reduced as much in the future as it has been in the past. New inventions and the development of old ones, quite unlike the beaters and jordans, to obtain the same results with the expenditure of less energy. are in process of adoption.

A considerable pumpage load is common to the beater and paper or board machine rooms. The operation of the pulp presses also requires considerable power, as do certain mills making highly compressed and glossed or supercalendered paper and those employing a large number of cutters for converting rolls into sheets.

The chief power load of the mill, after that of the beater room, is from the drying section. This load is due to bearing friction and overcoming the inertia of the drying cylinders. Beyond the relief obtainable from roller and other bearings, which are better than the standard journal, not much reduction in energy requirement may be expected here.

The modern drive for paper and board machines is by direct-current motors so interconnected electrically that the relative speeds between the sections of the machine and the absolute speed of the entire machine are changeable instantly through a considerable range, at the will of the operator. This corresponds to the old-time variable-speed steam engine, many of which are in service.

The special problem of steam and electric engineering with respect to pulp and paper mills is this: To reduce the energy requirement of the process, if by so doing the cost of fuel and boiler plant operation can be diminished. If not, reduce the heat requirements of manufacture; if that be impossible, find a use for the energy available from the necessary steam and apply it to the reduction of labor costs in the mill. Or, balance the requirements of steam and energy by devising ways and means of using any unavoidable surplus of one or the other to attain increased production of paper. The solution of these problems affords opportunity to practice the best and latest developments of the art and science of engineering.

Power in the Food Industry

By JOS. J. MERRILL

Chief Engineer, Corn Products Refining Co., Chicago, Ill.

IN THE food industry, as represented in the manufacture of corn products, the use of steam and heat is of much greater importance than the actual use of mechanical and electrical power. Progress, therefore, in this industry has been largely toward more economical generation of steam, and better application of steam and heat in the manufacturing processes. For example, in 1907 when this company began making a study of its use of power, a saving of 175 tons of coal a day in one plant was made on an expenditure of less than $500 through stopping the waste of steam in the manufacturing departments.

Up to that time little or no thought had been given by the men in charge of the factories to the efficient production or use of steam and power. The reason for this was that prior to 1907, managers, superintendents, and their assistants in all the factories were chemists, and had the control of everything in their hands. It was the chemist who developed the industry, and because a certain amount of chemical knowledge was necessary in the process, it was thought that he must run the

After the showing which had been made in this one plant in 1907, the production of steam and power and its use in all of our factories were put under complete control of an engineer, which in a few years brought about a marked change in the management of the factories. Ninety per cent of all the work involved in the manufacture of the products calls for engineering rather than chemical knowledge. Today, the managers, superintendents, and master mechanics of our factories are all engineers and they have all reached these positions by first learning how to make and use steam and power economically.

Costs of operation are based on the bushels of corn ground, which is the basic factor in the industry. In this industry the use of power is a minor element, but the use of heat and steam are of major importance. The plant, as well as the type of drive, must be designed with this in mind. A number of years ago the practice was to use steam-driven units scattered around through the plant to drive the various mills, pumps, and so on. Today, all pumping and generating equipment is concentrated in a single power plant. Mills and conveying equipment are motor driven.

Whereas 20 years ago 1,600 kw.-hr. and 7,800 boiler horsepower hours were required for every 1,000 bu. of corn ground, today, in a plant manufacturing the same product, every 1,000 bushels of corn ground requires 2,800 kw.-hr., but only 4,000 boiler horsepower hours. Large quantities of heated water are required in some of the processes and much heat for drying is necessary.

The reduction made in the consumption of coal has been followed by a reduction in the maintenance costs of our factories. In 1912, an assistant to the Chief Engineer of the Company was put in charge of the maintenance work in all factories. During the following year, 1913, the average maintenance in all our factories was 2.75 cents per bushel of corn ground. In 1926 the maintenance cost was 2.7 cents per bushel. Although the cost in 1926 was a fraction of a cent per bushel lower than in 1913, the comparative cost was much lower, when the cost of labor and material are taken into consideration during these periods. In 1926 our labor costs were 83½ per cent higher and material costs were 117 per cent more than in 1913. Based on 1913 labor and material costs, the maintenance cost in 1926 would have been 1.2 cents per bushel of corn ground, a reduction of over 1.5 cents, or $585,000 per year.

The good work that has been accomplished is due to a great extent to the way our engineering department is organized. There is a designing department where an entire factory or any part of one is completely designed; a construction department which does all the construction work (no outside contractors are employed on any of our work); the operating department which takes over the plant and operates it, when the construction work is finished; and the maintenance department. Each of these departments has an engineer in charge of it who has grown up in our business.

The Chief Engineer, who is responsible for all these departments, is also Chairman of the Manufacturing Committee, which controls everything having to do with the manufacture of all our products.

Factors that Determine Necessity for

Replacing Obsolete Equipment

ONE of the puzzling but important problems that has to be solved by every industrial operating executive is that of replacing obsolete electrical and mechanical power drive equipment. Barring complete failure or accidents that damage equipment beyond repair, it is possible to evade facing squarely the problem of replacement, for with proper maintenance attention it is possible to keep almost any piece of equipment in service practically indefinitely. To do this one must, however, be prepared to pay heavy operating and maintenance costs. On the other hand, to replace serviceable equipment without adequate justification is indefensible.

How, then, can the industrial executive determine when it is justifiable from an operating standpoint to replace equipment?

The answer to this question was sought from readers. Men in well-known plants were asked to enumerate the factors they consider to be the most important in determining the advisability of replacement. Supplementing these opinions, a number of manufacturers of equipment were asked to give their viewpoint on this subject.

Some of these answers were published in the article beginning on page 51 of the February issue. Other answers that have been received are given below.

In determining the need for replacement, H. D. FISHER, PLANT ENGINEER, *The New Haven Pulp and Board Co., New Haven, Conn., considers that trouble from the operating standpoint, and the amount of production delays are the principal factors to be considered. He also calls attention to the fact that there may be little economy in purchasing equipment that will eliminate a laborer, but require a more expensive workman to operate or maintain it.*

WE HAVE no definite schedule for replacing power drive equipment, as each case is judged as far as possible on its own merits. In a comparatively small plant such as ours this is not difficult, as certain men, the millwrights for each paper machine, the chief engineer for the power plant equipment, the electrician for the motors, and so on, are made responsible for maintaining their equipment in operating condition and advising of the necessity for repairs or replacements which they do not have facilities for making, subject, of course, to the general inspection of the superintendent and other higher officials.

Recommendations for replacing the equipment usually arise through these men or the superintendent when the amount of time required to keep the equipment in shape, or breakdowns resulting in loss of production, appear excessive.

The principal factors in determining replacement are trouble from the operating standpoint and loss of production; next to this, and usually associated with it, is excessive repair cost. Aside from its effect on these considerations age is of little consequence, as at times it seems as though the manufacturers employ their experience chiefly to see how much poorer and cheaper they can build their product and get by with it. In most of our equipment it is very difficult to obtain a sufficiently accurate measure of efficiency to warrant replacement on this ground.

Other things being equal, we prefer to buy equipment of the same make as we already have, providing it will give us sufficient duplication to reduce the storage of spare parts. Aside from this, the precedent of using the same make of equipment in choosing future equipment has no weight.

In purchasing new equipment we aim at minimum over-all cost, capital charges, power requirements, and repairs. In every case, the first consideration is continuous operating reliability, as in a paper mill the processes are so connected up that a shut-down of a comparatively small and inexpensive piece of equipment may tie up the whole mill and completely stop production. Reliability usually includes saving in maintenance and repair costs and, of course, design and construction which allow of easy access and ready repair are very important considerations. For minor auxiliary equipment which is used infrequently, first cost is more of a consideration, but the writer's experience has been that, within reason, price should be of no consideration whatever as compared with reliability and freedom from repairs. Of course, as between what are apparently equally well built and substantial machines, we would be inclined to purchase the lower priced one.

The matter of saving in operating labor affects the decision to replace equipment rather than the choice between different pieces of new equipment, but we find many of these arguments are illusive. There is often a tendency to eliminate a laborer by the purchase of a machine which eventually requires a much higher paid mechanic to run it or keep it in shape.

Operating trouble is a most important factor in determining replacement, says R. N. VINING, ELECTRICAL SUPERINTENDENT, *The Colorado Fuel and Iron Co., Pueblo, Colo. He describes the method used in estimating the present value of equipment in service, which forms the basis on which comparisons with new equipment can be made.*

IN THE replacement of equipment we consider trouble from the operating standpoint as a most important factor. Next comes age, in so far as it affects improvements in construction, standardization, and "quick change" features in the event of breakdown. In the case of control equipment, improved types of overload protection, acceleration features, plugging arrangements, automatic features and so on are important factors. Third, excessive repair costs and the general efficiency of the old equipment are both balanced against the cost of new apparatus.

We keep costs of equipment as follows: The value of the apparatus is determined by charging off a certain amount each year for depreciation. The amount charged off, plus interest on the invested capital represented by the present value, plus taxes, plus maintenance and operating costs give us a basis on which comparisons can be made. With these data the cost of operation, including all of the above items plus the savings or the value of the increased production obtainable from new designs, helps considerably in deciding the best equipment for us to use.

If we find that one piece of equipment slows down a process involving other equipment, either from the operating standpoint or due to trouble, improvements to this drive receive first attention.

Excessive repair cost and operating trouble are considered by R. R. SCHELLENGER, ELECTRICAL ENGINEER, *Elk Horn Coal Corp., Wayland, Ky., to be the most important factors in deciding the necessity for replacement. In his case power costs are so low that any possible saving is not a decisive factor in the selection of new equipment.*

WE DO not have what could be called a definite schedule for replacement of equipment, but we do keep records which have a direct bearing on this question, and recommendations for replacement usually originate in my office.

We keep a record of the repair cost on all important pieces of equipment, and consider that excessive repair costs and trouble from an operating standpoint are the most important factors in determining the necessity, or advisability, of replacement. The age of the equipment cuts but little figure if maintenance is properly looked after. Furthermore, our power costs are so low that the item of increased depreciation on a more efficient, but more expensive, machine will outweigh the saving in power costs.

As a general rule, we replace obsolete equipment with apparatus of the same make, although this depends entirely upon the performance record of the machine in question. In any event, saving in operating labor, in maintenance and repair costs, and desirable features of design and construction, rather than first cost, are the determining factors in the selection of new equipment. It is rather difficult to say which of these three factors is given the most weight, as this depends on the location of the equipment and the kind of service it renders.

If it can be shown that the cost of replacing or altering equipment can be paid for out of savings or increased production within a year or so, CARL RETTER, CHIEF ELECTRICIAN, *Allied Paper Mills, Kalamazoo, Mich., makes the change without further delay. Operating troubles and suggestions for improvements are discussed with department heads in weekly meetings.*

WE HAVE weekly meetings of the foremen of the different departments. Here the problems of these departments are discussed, and all weak points are brought to light. If we find that someone has had trouble with any of the equipment, or that he has any difficulty in keeping up production in his department, the matter is at once taken up by the production manager, master mechanic, and myself. If we find that a certain machine or part has given more trouble than should be expected, or that a larger or faster machine would increase production, or possibly changing controls to a more convenient place, or replacing manual with automatic, float or pressure control would be advisable, the matter of cost is gone into. If it can be shown that the investment will pay for itself in about one year the change is made without any further discussion; if the expenditure is a large amount requiring two or more years to pay for itself, the matter is taken up with the management.

If any of the men have any suggestions to offer, these are given careful consideration.

The cost of all repairs to equipment is kept on file; production time lost, with time required to repair equipment that has failed, is also filed.

In determining obsolescence, I do not see why age of equipment is to be considered, if it does not give trouble from the standpoint of operation or excessive repair costs, assuming, of course, that it does not hold up production to the extent that new equipment would more than pay for itself.

In replacing equipment, what we buy is governed by past experience and the possibilities that seem to be offered by new devices available.

In the selection of new equipment, saving in operating labor and low maintenance and repair costs should, in my estimation, be the governing factors.

Improvements in the design and construction of both a.c. and d.c. motors make extensive repairs to motors ten years or more old questionable from the standpoint of economy, according to J. W. COREY, ASSISTANT SALES MANAGER, *The Reliance Electric & Engineering Co., Cleveland, Ohio.*

THE electrical industry is so young and the life of an electric motor is so long that replacement of old motors has not until lately been an item of interest to the average plant man.

We have had, of course, the change from direct to alternating current in many plants, but in this case the primary reason has been to secure central station power at rates cheaper than an isolated plant could make it. Most of these changes swept too clean and it has usually been found necessary to convert some of the alternating current back to direct current to take care of adjustable-speed and other drives.

It is questionable whether it pays to rewind stators and replace bearings on squirrel-cage motors of 5 hp. rating and less that are ten years old. Few motors built before that time had cast or welded rotor end ring construction, and although the old soldered rotors can be welded they are inefficient and the power factor is poor. Furthermore, such repairs are expensive.

Again, ten years ago ball bearings in motors were very costly. The lower maintenance on motors equipped with that type of bearings is quite universally admitted and new motors can be purchased with them at comparatively slight extra cost.

To illustrate, I will quote the prices on two sizes of three-phase, 60-cycle, 220-volt squirrel-cage motors in this class, as given by a Cleveland repair shop:

Motor, 1,800 R.p.m.	New Motor with Ball Bearings	Rewinding and New Sleeve Bearings
1 hp.	$39	$33
3 hp.	52	42
7½ hp.	79	60

It will be noted that as the motors get larger it becomes well worth while to repair them, but the smaller machines should be replaced with new motors unless mounting limits make this inadvisable.

On direct-current motors with more complicated windings far greater strides in improvement have been made in the past 10 to 15 years. Commutating poles have come into use, giving longer life and lower maintenance cost than was possible with older motors. Insulation of brush studs, field and armature coils has been improved. Better commutators are being manufactured, and anti-friction bearings in motors eliminate oil and lubrication troubles.

It is my opinion that a careful analysis of costs will show that with any direct-current motor from 10 to 15 years old, or older, that does not have interpoles the following statements hold true:

(1) If a new commutator is necessary a good many cuts must have been taken off, denoting much sparking and consequent need for careful maintenance.

(2) Megohm readings on the fields will show that they have about reached their limit of usefulness.

With these points in mind determine the cost of all repairs that must be made soon. Check their cost, and the possible loss of productive time against the cost of a new motor, and it will be found that it will pay to scrap any direct-current motor up to 30 hp. rating that has reached this condition.

It is not the intent of this article to limit the life of motors to 10 or 15 years, as we know of many motors 25 to 30 years of age that are still operating satisfactorily and will continue to do so for years to come.

However, I should like to bring to the attention of operating executives a few of the conditions under which repairs cease to be economical.

On the other hand, proper inspection and prevention of trouble can cut maintenance costs in two and double the life of a motor.

If a motor is in a dirty place, clean it often and try to design a protective cover of some kind. The motor manufacturer can probably offer helpful suggestions.

If a motor overheats find out the cause at once, correct the trouble and save a burnout.

If a direct-current motor is sparking, no matter how little, repair it at once. Sparking increases as the commutator gets rough and will soon make expensive repairs necessary, if the trouble is not corrected.

Proper attention to these three points will save you money:

(1) Frequent inspection of motors and control equipment.

(2) Cleanliness.

(3) Prompt correction of symptoms before actual trouble occurs.

Construction details of

Short-Throw Coils for Chorded Windings

together with examples of the savings in copper and other advantages obtained by the use of such coils

By A. C. ROE
and
D. H. BRAYMER
Consulting Editor, Industrial Engineer

MANY of the present-day designs of induction motors and alternating-current generators employ short-throw coils in what are known as chorded windings. This construction results in improved performance, since the lessened length of copper wire reduces the heating effect and the shorter coil and end connections reduce the inductance of the coil ends. The combined effect is to lower the impedance of the winding, with improvement in power factor and efficiency. This article deals with the construction of short throw coils and the benefits obtained by their use.

THIS article is written to assist those who have occasion to rewind standard present-day designs of induction motors for a different number of poles and are required to lay out new coils of the short throw type.

The following examples and the accompanying diagrams illustrate an easy and accurate method of laying out these short throw coils to secure the advantages that are possible through their use. Fig. 1 is constructed to show the plan view of the coil ends required for a ten-pole motor having 144 slots with different coil throws from full pitch of 1-and-15 to half pitch of 1-and-8.

The line *XX* represents the end of the slot sections of the coil and the line *FB* the distance between the line *XX* and the center line of the pin at the diamond point of the coil after being pulled to shape. This line *FB*, shown as *HT* (for height) in Fig. 1 and in Table I, also indicates the coil end extension beyond the cell sections. It will be used to show the reduction in over-all length of the short throw coils. This reduction in length is shown in Fig. 1 at the left, by means of the horizontal lines marked 1 to 8 through the center line of the shuttle pin after pulling.

The line *FB* also locates the center line of the coils, and each coil throw from 1 to 15 down to 1 to 8 is shown by the numbers 1 to 8 in the first column of Table I as worked out for each coil throw listed in that table.

The line *EG* in Fig. 1 for No. 8 coil pitch is for 50 per cent pitch, whereas the line *FB* is for full or 100 per cent pitch. The angle *ABC* in Fig. 1 gives the 1 to 15 pitch, coil end extension and the angle *AEF* gives the 1-and-8 pitch.

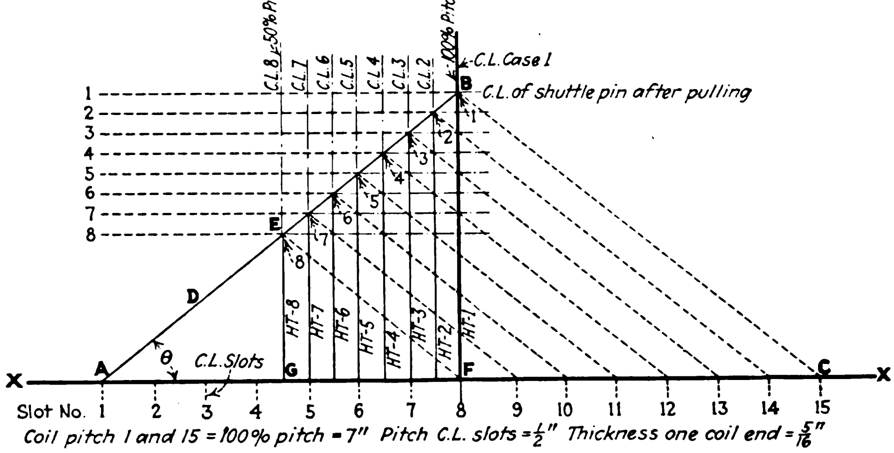
In Table I, column 1 lists the eight coil pitches considered from full to half pitch. Column 2 gives the coil pitches considered and column 3 the location of the center line of the coil pitch in each case. For example, in case 4, column 3 shows that the center line of this coil lies between slots 6 and 7 and the line *HT*-4 shows its location in Fig. 1. Column 4 gives the total over-all reduction in length—that is, the distance between the horizontal lines 1 and 2 times two. Column 5 lists the lengths of the line *HT* for each case. Column 6 gives the length of the line *D*, or the distance between the point *A* and the intersection of the line *HT* and the center line for the shuttle pin for each case. It is the length of this line that governs the length of the shuttle. Column 7 gives the length of the shuttle required. This is based in Fig. 1 on a 7-in. cell length for both sides and twice the length of the line *D* for each case. Column 8 gives the length in inches that the total length of the shuttle between the center lines of the pins (*L* in Fig. 3) is reduced by the reduced coil throw for each case.

From Table I it will be found that the 1-and-10 pitch reduces the over-all length of the coil $2\frac{1}{32}$ in. and cuts $3\frac{3}{16}$ in. off the shuttle. For each turn in the coil this represents a saving of $6\frac{3}{8}$ in. of the copper wire used.

A layout such as shown in Fig. 1 is not difficult to make for any coil and it is useful to obtain a coil extension that will give good clearance between the ends of a coil and the bearing brackets. In Fig. 1 it has been assumed that both coil cells are of the same length, whereas in actual practice one cell is longer than the other; this will change the actual dimensions given in Table I and in Fig. 1, but the proportions of savings will still remain the same. Also Fig. 1 does not show all of the savings to be made in the total copper

Fig. 1—Plan view of the coil ends required for a ten-pole stator having 144 slots with different coil throws from full to half pitch.

The line *XX* represents the end of the slot section of the stator and the line *FB* the distance between the line *XX* and the center line of the pin at the diamond point of the coil after being pulled to shape. The reduction in length of this line *FB* for the different coil throws is shown by the horizontal lines at the left marked 1 to 8.



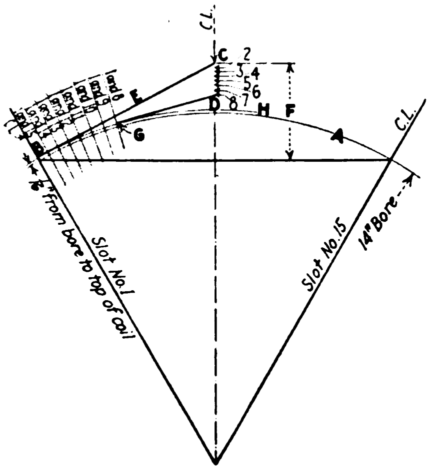


Fig. 2—This diagram shows that the shorter the coil extension and pitch the lower the diamond point of the coil can be to the bore of the stator.

The arc *A* represents the air gap line or bore of the stator and the line *H* the distance the coil lies above the air gap line, or about 1/16 in. The line *BC* represents the top of the coil end for various coil throws with resulting differences in the length of the line *F* to bring the point *B* in Fig. 1 on *C* of this diagram above the air gap a sufficient distance to keep the coil clear at all points of the air gap.

length by chorded pitch windings, since the shorter the coil extension and pitch the lower the diamond point of the coil can be made in reference to the bore of the machine. This is shown in Fig. 2 and in Table II.

In Fig. 2 the arc *A* represents the air gap line or bore of the stator and the line *H* the distance the top of the coil lies above the air gap line. In Fig. 2 the center line has been kept fixed and the throw moved in a half slot pitch for each case. The line *BC* in Fig. 2 represents the top of the coil, and this line is usually made so as to keep the coil below the air gap line. For each case, then, the line *BC* has been drawn and the distance *F* measured and recorded in Table II; also the lengths of the lines *E* as *BC* or *GD* for each case have been added to Table II.

Table II also gives the difference between the line *BC* or *E* for the full pitch 1-and-15 and each possible throw down to 1-and-8 or half pitch. The maximum saving in the difference in line *E* for the 1-and-8 pitch is 1 13/16 in.

Thus from Figs. 1 and 2 it will be found that a short throw coil results in a shorter length of copper from the fact that any coil extension is composed of two factors: (1) The length of the line *AB* in Fig. 1 in a flat place and (2) the difference between *AB* of Fig. 1 and *BC* of Fig. 2 which is required to bring the point *B* in Fig. 1 or *C* in Fig 2 above the air gap a sufficient distance to keep the coil clear at all points of the air gap.

The layout of Fig. 2 is not a continuation of the diagram in Fig. 1, but represents figures taken at random to illustrate the points brought out.

In Tables III and IV it is assumed that the savings given in Tables I and II are for any one coil and the

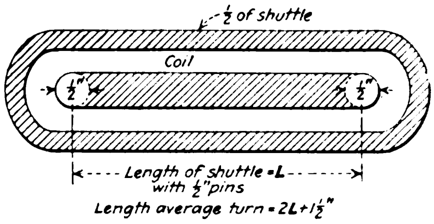


Fig. 3—A shuttle made coil showing the length of the shuttle (L) and the average length of the turns of the coil.

effects of the reduced or chorded pitch on the effective turns, line voltage and total length of copper in inches saved per coil are recorded. In both these tables under column 7 are listed the total lengths of copper per coil for each case. This was found by first assuming a coil having ten turns of one No. 9 B. & S. double cotton-covered wire arranged two wide by five deep. Since one insulated No. 9 wire has a diameter of about ⅛ in., five such wires would be ⅝ in. high. Then assuming a ½-in. pin for the shuttle in Fig. 3, it is found that the average length of a

Table II — Information on Short Throw Coils Based on the Diagram of Fig. 2. All Dimensions Are in Inches

Coil No.	Length of Line *E*	Length of Line *F*	Differences for Lines *E*	Coil Pitch
1	4	1 13/16	. . .	1 and 15
2	3⅞	1 13/16	⅛	1 and 14
3	3 13/16	1 13/16	11/16	1 and 13
4	3 5/16	1⅝	11/16	1 and 12
5	2 15/16	1 7/16	1 1/16	1 and 11
6	2⅝	1 7/16	1⅜	1 and 10
7	2 5/16	1 13/16	1⅝	1 and 9
8	2 3/16	1½	1 13/16	1 and 8

turn of wire is equal to $2L$ and the circumference of a circle 1⅛ in. diameter, which is about 1½ in. Then L in Fig. 3 for each case equals L as in Table I plus twice the difference between line E as recorded in column 4 of Table II.

In Tables III and IV the first column lists the coil pitches in column 2. Column 3 gives the coil angle in electrical degrees; column 4 the cord factor for each case; column 5 the effective turns, which are found by multiplying the total turns per coil by the chord factor; column 6 the line voltage for each coil pitch, which is equal in each case to 220 times the chord factor; column 7 the total inches of copper in the ten coil turns for each case; column 8 the total number of physical turns per coil; column 9 the total savings in inches of copper per coil for each throw.

By studying Table III, it is found that case 4 reduces the total turns to an effective value of 9.32 or 9¼ turns, which reduces the line voltage to 205, or not quite 10 per cent, which should cause no trouble. The starting and pull-out torques will be increased, and from column 9 of Table III it is found that for case 4 a saving of 63¾ in. of copper is effective for each coil. By carrying the study further to Table IV it will be seen that the physical turns have been increased to a value that will raise the effective turns to give a working voltage for the coil throw used.

Then by comparing cases 6 and 7 it is found that the greatest saving is obtained with case 6, whereas case 7 shows a good saving and has a shorter coil extension than case 6.

By comparing case 4 with case 6 it is found that even with an added turn, case 6 shows a better gain in copper saved and also a shorter coil extension. Thus, all things considered, if there is room in this slot

Table I—Information on Short Throw Coils Based on the Diagram of Fig. 1. All Dimensions Are in Inches

Coil No.	Coil Pitch	Center Line of Coil Pitch	Reduction in Length of Coil	*HT*, Inches	*D* Inches,	Length of Shuttle	Reduced Length of Shuttle
1	1 and 15	1 and 8	. . .	2 13/16	4¼	16	. . .
2	1 and 15	1 and 7½	5/16	2 13/16	4 5/16	15 9/16	½
3	1 and 13	1 and 7	13/16	2 11/16	3 13/16	14 11/16	1 5/16
4	1 and 12	1 and 6½	1 3/16	2 13/16	3 9/16	14⅛	1⅞
5	1 and 11	1 and 6	1 13/16	2 9/16	3 ¼	13 7/16	2 9/16
6	1 and 10	1 and 5½	2 9/16	1 11/16	2 13/16	12 11/16	3 5/16
7	1 and 9	1 and 5	2 5/16	1 13/16	2 9/16	12¼	3¾
8	1 and 8	1 and 4½	2 13/16	1 9/16	2 13/16	11 13/16	4 13/16

Table III—Saving in Copper When Winding Coil of Ten Turns of No. 9 B. & S. Gage Double-Cotton-Covered Wire

Coil is wound two wires wide and five deep, with different coil pitches, for a 144-slot, 10-pole stator.

Coil No.	Coil Pitch	Coil Electrical Angle, Deg.	Chord Factor	Effective No. Turns	Line Volts	Inches Copper in Coil	Total Turns	Saving Copper, Inches
1	1 and 15	87½	0.99905	10.0000	220	345	10	....
2	1 and 14	81¼	0.98836	9.8836	217.44	311¼	10	33¾
3	1 and 13	75	0.96592	9.6592	212.50	298⅝	10	56⅜
4	1 and 12	68¾	0.93201	9.3201	205.04	281⅛	10	63⅞
5	1 and 11	62½	0.88701	8.8701	*195.14	262⅛	10	82⅞
6	1 and 10	56¼	0.83147	8.3147	*182.92	243⅝	10	101⅜
7	1 and 9	50	0.76604	7.6604	*168.53	225	10	120
8	1 and 8	43¾	0.69151	6.9151	*152.13	206½	10	138½

*Not enough turns to meet line voltage conditions. See Table IV for required turns per coil.

Table IV—Same as Above Except for Increase in Turns per Coil to Give Working Voltage for Coil Throw Used

5	1 and 11	62½	0.88701	9.75711	214.65	286⅜	11	58⅝
6	1 and 10	56¼	0.83147	9.14617	201.22	264⅛	11	80⅞
7	1 and 9	50	0.76604	9.19248	202.23	270	12	75
8	1 and 8	43¾	0.69151	8.98963	197.77	368⅛	13	76⅞

for the extra turn, case 6 of Table IV would give the maximum savings and the shortest coil extension.

It will be observed that a few sketches and tables such as given in this article, if laid out for any given coil design, will reveal a number of interesting points and provide a method for laying out coil designs to suit any particular case.

Table IV shows that to get a working voltage that is barely up to the 10 per cent limit for the half pitch it is necessary to use thirteen turns per coil. A further saving can be had on the short throws by making the windings more compact by reducing the air space between coils.

A further discussion on chorded pitch windings is contained in the following books: "Connecting Induction Motors," by A. M. Dudley, and "Connecting and Testing D.C. Machines," by Annett and Roe, both published by the McGraw-Hill Book Company, Inc., New York City.

Use of Belts on Motor Drives

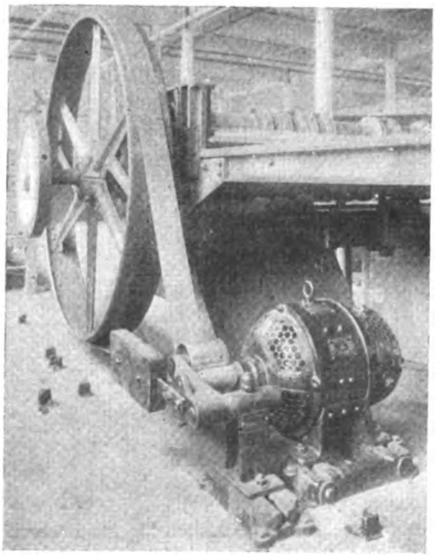
(Continued from page 105)

The gravity idler pulley is generally supported on a hinged arm and is weighted to maintain a given tension on the slack side of the belt at all times. The idler pulley is so located that it increases the arc of contact of the belt on the smaller pulley, thereby increasing the traction at this limiting point. There are a number of commercial applications of this principle on the market, some of which are shown in the accompanying illustrations.

When gravity idlers are used there is no need for wide separation of pulleys and short belt centers may be used, which results in economy of floor space and a material reduction in the length of the belt. Also, higher pulley ratios may be used because the arc of contact on the smaller pulley is not affected, as on an ordinary belt drive, but may be increased considerably over 180 deg. With higher pulley ratios, higher speed motors may sometimes be used. The short-center drive compensates for belt stretch, within limits, and maintains a required belt tension without an excess, due to increasing the arc of contact, which decreases the necessary belt tension and consequently the pressure on the bearings.

Here is an example of the extremely high reduction ratio that is possible with short-center drives.

This drive on a machine in a box factory has a 30:1 pulley reduction. In addition, the motor is placed up close to and under the machine where it is out of the way. This is a Pulmax short-center drive installation.



Gravity idlers are not adapted for use where direction of rotation may be reversed. They have many commendable features, however, and their more general use appears justified. For example, vertical belt drives or drives operating at an angle greater than 45 deg. from the horizontal can be made to operate much more satisfactorily and with narrower belts and lower belt tensions by the use of such short-center drives. Endless belts should be used on these idler drives.

Another form of short-center modified belt drive is designated commercially as the Texrope (Allis-Chalmers Manufacturing Co.) drive. Grooved sheaves are connected by a number of V-belts of rubber fabric which are used in multiple to transmit the power. Some installations of this drive are shown in accompanying illustrations. This drive has a number of commendable features. It is simple and low in first cost. It was first developed for application to textile drives to eliminate slip, jerks, and lost motion resulting in excessive thread breakage. Its use has extended until it is now available for drives of over 1,000 hp. rating.

The maximum recommended speed reduction ratio for a Texrope drive is 7 or 8 to 1. Higher ratios are not recommended unless the centers are relatively long so that the arc of contact on the small sheave will be 120 deg. or more. The best belt speed is about 3,000 to 3,500 f.p.m., but speeds from 1,500 to 5,500 f.p.m. may be used. Several sizes of Texropes are used to cover the range of powers. The Texropes are endless loops and the center distances or sheave diameters must be suited to the belt lengths available.

Any number of Texropes may be operated in parallel to obtain the required capacity but excessive sheave or pulley width is not desirable because of flexural pull on an overhung motor shaft. Although no initial tension is required, the Texropes should be neither too loose nor too tight; hence a sliding base or rails under the motor are desirable.

Another article by Mr. Fox that will appear in an early issue will discuss the use of chains for connecting the motor to the driven machine or other load.

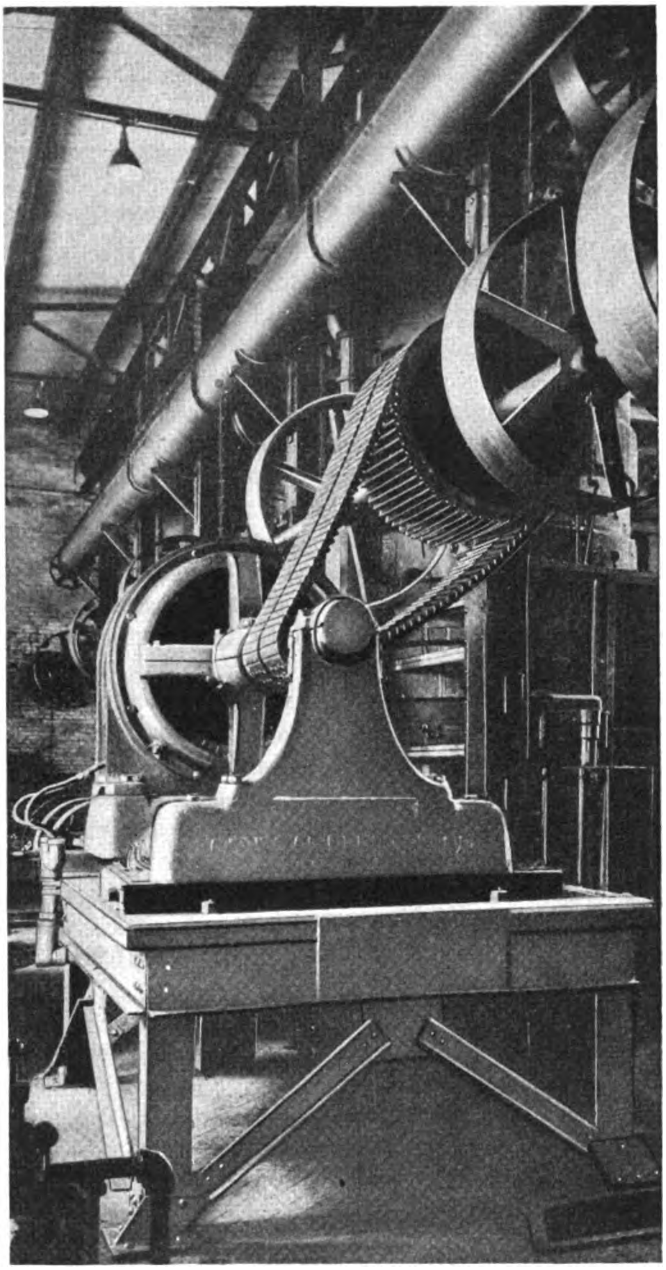
Construction Changes Under Difficulties

oftentimes tax the unusual ingenuity that an operating man must have

WHEN it comes to making changes in an existing plant, the big problem in almost every case is to find a way to get the required equipment in the place where it should go. It is a simple matter for a designing engineer to lay out a new floor of equipment with its required drives, and then, so to speak, build a building around this layout. In the case of later changes, however, most conditions are fixed—side walls cannot be moved, stairways cannot be torn out, steam, water and air piping is there to stay, and so on. It's simply up to the operating superintendent to get in between or around all of this and still get the results that are desired.

TAKE the case of a motor drive for instance, the moving and changing of which are always a part of a progressive operating program calling for speed changes, rearrangements of machines, and so forth, to suit new requirements or changes in the course that production follows through the plant. The production manager in working out a new movement of materials at machines, with almost no exceptions, says, "We'll place the machine here and Bill (the operating superintendent) will find a way to hook up the motor." And so Bill is called in to finish the job by main strength and awkwardness, plus all the ingenuity at his command. And his ingenuity might in many cases well be copied by others in making some new layouts.

THE accompanying photograph shows an example of such ingenuity under conditions that cannot be revealed in detail in a picture. For instance, the motor was on hand, and was of a design that is not easy to mount in close quarters. It could not be hung from the ceiling, first, because of the interferences and, second, because it would be hard to get a rigid support free from vibration. The only other solution was the giving up of the necessary floor space for a substantial platform constructed of such a height as to provide practical centers for the chain drive. This construction made it possible also to locate the motor drive at a point on the lineshaft so that it could be loaded on both sides of the driven sprocket, a condition that would not have been possible had the motor been suspended from the ceiling. While this was not the least expensive drive arrangement that could have been made, and probably would not have been used had the motor drive been installed when the lineshaft was put in, it has given good service and has justified the trouble it took to devise the scheme and work it out.



THIS particular installation I have referred to simply to bring out the kind of problems that are encountered in operating work, with nothing much said about them. I dare say that those who read this can point to several in their own plant which they have already forgotten. In that case, if you recall something particularly tough about a job, just take the time to draw a rough pencil sketch and send it to me with a description of the troubles that were encountered. I want not only to call this to the attention of others who may be interested, but to record the information in some appropriate way as evidence of the fact that the titles of superintendent, master mechanic, chief electrician, and the like, call for engineering ability of a high order and are worthy of compensation in keeping with the results secured.

Practical Pete

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Editor*

Single-Phasing Can Be Stopped

WHEN a burned-out motor comes into a repair shop, whether this is operated by an industrial works or is an outside commercial shop, every possible check should be made to determine the actual cause of the burnout, particularly as to whether it might be due to single-phasing. If the trouble was single-phasing this fact can be determined unless the winding is completely roasted out.

In most cases single-phasing can be traced to carelessness on the part of some one; either the workman who installed the motor or starter, or the operator who replaces burned-out fuses. When a motor is running single-phase, that fact is made known by an unmistakable growling, and frequently more than one fuse will be blown. If two are blown and only one is located and replaced, the motor can be started again from the line side of the switch, which is connected ahead of the fuses, and when the switch is thrown over to the running position, the motor will still be operating single-phase.

Such carelessness in checking fuses is common, and in the case of single-phase operation of a motor is certain to be expensive. From a careful check on every burned-out motor winding before it is stripped off much can be learned that will save time and future repair costs. In case carelessness such as described cannot be eliminated, the only solution of single-phase burnouts is adequate protection of an automatic nature. This is not so expensive over a period of years as its first cost may appear, when considered alone.

Make Inspection Routines Cover Out-of-the-Way Equipment

MANY industrial executives have found that the best method of reducing operating interruptions is through organized inspection and maintenance procedure. The proper plan to follow is determined largely by the extent of the plant, the industry, and the operating service. In practically all cases daily inspections are desirable and most valuable.

Routines once established and occasionally checked up usually run along smoothly. Difficulty is sometimes encountered, however, in adapting the routine to the necessary changes in location or additions to the equipment. For example, one large Midwestern concern has divided its plant up into districts in each of which a route man makes the daily inspection and cleans, oils, and does the work that is necessary to maintain the equipment in operating condition.

One day a motor failed and an examination showed obvious lack of attention. In checking up to determine the responsibility for the neglect, it was found that the motor was installed in an out-of-the-way place, which was not within the territory served by any of the route men, and none of them had been notified to include the motor in his route. It had been operating without service for over a year before it became overheated and caught fire.

Some routine or method should be provided for notifying the route men about these unusual situations. Also, it is well for the head of the department or his assistant to check up every drive occasionally, to make sure that nothing is being missed. Furthermore, when a change or new installation is made, some individual other than the route men should be given the duty of making frequent inspections until it is assured that the equipment is operating satisfactorily.

Trends and Developments in Industry

FIGURES reported in the 1925 Census of Manufactures, which has been made biennially since 1919, reveal a number of interesting trends and developments in industry. For a number of years there has been a tendency for an increasingly large per cent of the total output of manufacturing industries to be produced by large companies, especially those whose annual value of product is over $1,000,000. This trend is in part revealed by the fact that the average number of wage earners per establishment increased from 38.94 workers in 1914, to 44.72 workers in 1923.

While these changes have been going on, there has also been a marked increase in the efficiency of production. For the same unit of production there were required, in 1923, 25 per cent less workers and 17 per cent less salaried officers and employees than in 1914. Part of this is due to the increased efficiency of management, and part to the increased use of power. In 1914 the average horsepower per establishment was 125.8 as compared with 168.5 in 1923; at the same time the horsepower per wage earner increased from 3.2 in 1914 to 3.7 in 1923.

Further evidence of concentration of industry is indicated by the returns for 156 separate industries. There was a decrease of 2.7 per cent in the number of establishments engaged in these industries in 1925, compared with the number that were manufacturing the same product in 1923. The number of wage earners also decreased by 1.9 per cent. Despite the decrease in both the number of establishments and the average number of wage earners

employed by them, the value of product increased 6.2 per cent.

The trend toward the further use of power in manufacturing processes is shown by an increase of 8.3 per cent in the primary power installed in these plants. In 1923 these same industries were employing an average of 122.7 hp. per plant. In 1925 they were using 140.2 hp. The horsepower per wage earner during the two-year period rose from 2.17 to 2.40.

Every plant manager can profitably bear in mind not only the fact that the horsepower per worker in American industries is rapidly increasing, but that this tendency is largely if not entirely responsible for our commercial supremacy and the development of our industries to their present status. The operator who does not take full advantage of every opportunity to replace hand labor with power-driven devices is putting his plant under a severe handicap in meeting competition.

Let Equipment Write Its History In Service Records

ANY operating executive who does not keep a complete service record for all important pieces of equipment is failing to take advantage of a most useful source of information. Intelligent selection and operation of equipment requires thorough knowledge of a number of important factors that comes largely as the result of experience. Among these factors are the reliability of the equipment, its suitability for the service conditions, amount of maintenance attention required, and cost of repairs over a reasonable period of time. This information can be used to advantage in a number of ways.

In the first place, unless there is a convenient method of checking up some of these points, undesirable and costly operating conditions may go unnoticed for a long time. Frequent inspections and careful repair work will go a long way towards reducing preventable breakdowns, but they will not necessarily improve operating conditions, or compensate entirely for defects in design or poor judgment in the selection of equipment.

Again, when a new item of equipment is to be selected, the information given on the service record of a similar item of the same make, or on the record of the device that is to be replaced, may prevent costly errors.

Every piece of equipment plainly tells us everything that we want to know about it, in terms of actual performance on the job. Its good points are easily seen by those who will take the trouble to watch it closely, and it reveals to us from time to time its weaknesses and troubles. Nevertheless, it remains for us to record the facts in such form that we can make use of the practical operating information that they contain.

Help-Yourself Oil Storage Is Costly

THE management of a large industrial plant paid well for the lesson which they recently learned in the handling and storage of lubricating and paint oils, and other liquids used in production and plant operation. All of these materials were stored on a "help-yourself" basis. No records were kept on the use of any of these materials, and so it was not known whether too much was used. The discovery of the waste was made from the outside.

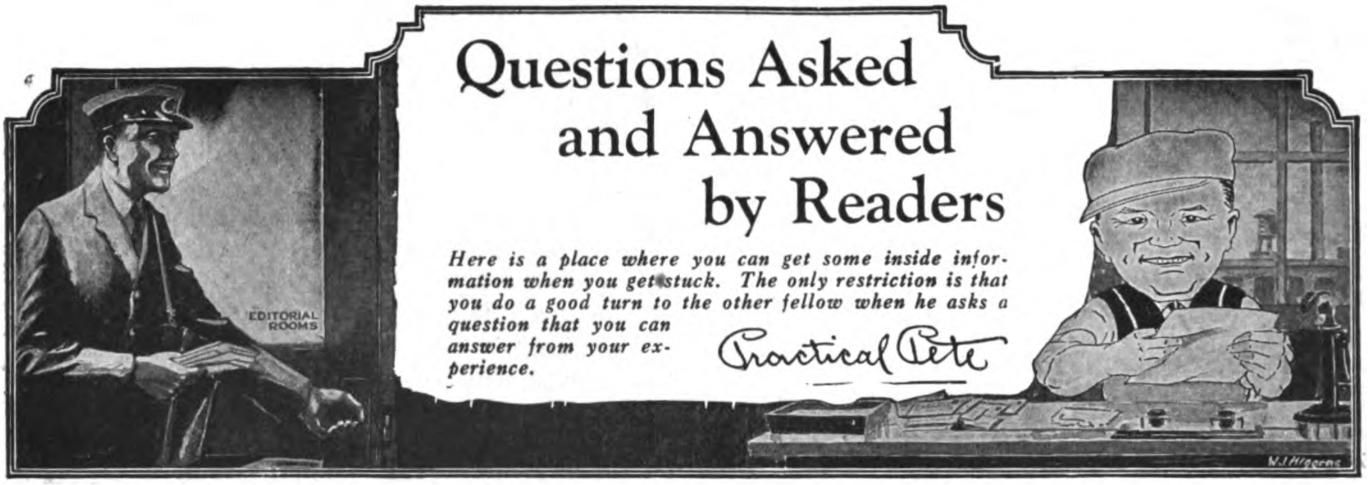
An enterprising laundry soap salesman set out to discover why the workmen's families did not buy much laundry soap from the village storekeeper. By means of a house-to-house canvass, he soon learned that many of the housewives were using a high-grade liquid soap which Bill, Jim, and Mike brought home from the factory. A request for an opportunity to bid on the plant's liquid soap requirements disclosed the quantity used. A simple problem of dividing this by the number of men employed showed that each employee was using an unusually large amount of liquid soap per month. To complete the story, there is now an increased market for soap in that town, and also a man in charge of the oil storage.

In the meantime, comparisons of the quantity of other liquids used against what should have been used showed that the consumption of several was far in excess of what it should be. This loss was immediately checked. Further investigations are now being made to determine the best plan for storage and handling of lubricants and other liquids.

Although there may be an inclination to criticize the dishonesty of the men, the loss could more justly be blamed upon the laxity of the management. When valuable materials are placed for each man to help himself and the men know that if a gallon or two is lost, or wasted, or spilled on the floor no one in charge seems to care about it, they can hardly be blamed for taking some.

Several salesmen had tried to interest this company in storage tanks and equipment for handling liquid materials, but the management always maintained that such equipment was not needed and that they were saving its cost and the expense of operating it. A close investigation, however, soon proved that the plant had, in other ways, paid for the necessary equipment many times over, and still did not have it.

Although such an excessive amount of waste is probably unusual in industrial plants, less striking examples are not uncommon, especially in connection with the storage and handling of oils and similar liquids. Plants which have installed tanks and other facilities for quantity storage of liquids will often find it profitable to investigate the handling and application of these after they are issued to the men.



QUESTIONS

Who Can Answer These?

Effect of Commutating Poles on Magnetic Field

I have noticed that some of our d.c. interpole machines are equipped with one commutating pole per pair of main poles, while others have one commutating pole for each main pole. In cases where one commutating pole is used per pair of main poles, is there any unbalancing in the magnetic field that will cause cross armature currents? Your opinion will be appreciated.

Seattle, Wash. W. M. P.

Testing Alignment of Right Angle Shafts

I wish some reader would help me out with some suggestions on a method of testing two shafts mounted at right angles and connected by bevel gears. The short shaft with the bevel gear consists of two 16-ft. sections of 2 3/16-in. shaft. The main 2 15/16-in. shaft is 60 ft. long. I am having trouble due to wear of the bevel gears and think that it is due to misalignment. What is the best way of checking this right angle? Also, how can I be sure that the two shafts are at the same level?

Cleveland, Ohio. E. H. G.

Cause of Short Life of Lamps

In our knitting department there are many belts, every other one being crossed. The wiring for the lighting system in this department is enclosed in conduit, which is grounded. I am using the No. 622 Holophane lighting unit, which is a glass reflector. Although I have used both 110- and 115-volt, A 23 and PS 25 lamps, respectively, on a circuit that indicates a constant voltage of 106 volts on a recording voltmeter, the lamps in these units last only about 100 hr. I shall appreciate any information that readers can give me as to why our lamps have such a short life, and how I can remedy this condition.

Newton, Mass. D. C. S.

Trouble With Squirrel-Cage Motor

On a dust collector in our cement plant we recently had occasion to replace a 5-hp. motor with a very old 10-hp. motor that had been standing in our store-room for some little time. We desired to speed up the fan of a dust collector and thought that this motor would do it inasmuch as it was rated at 850 r.p.m., 13 amp., 10 hp., 440 volts three-phase. After installing the motor and starting it, the resulting speed on the motor was only 250 r.p.m. while the current per phase was 8½ amp. After taking the belt off the motor and dust collector and letting the motor run idle the speed went up to 770 r.p.m. while the current decreased to 6 amp. per phase. I have never seen a squirrel-cage motor behave quite in this manner and cannot understand how the speed can drop as low as 250 r.p.m. without the load current going up to even normal rating. There was no sign of heating no matter how long the motor ran. It occurred to me that possibly some one had tampered with the coil connections so I opened up the motor and found the stator to be connected single circuit star. Can any reader suggest why this motor behaved in this manner?

Detroit, Mich. R. W. B.

How Should This Blower Be Driven?

I should like to have the advice of our readers on a drive problem. I have a blower with an 8-in. pulley which will be driven by a 720-r.p.m., 25-hp., three-phase, 25-cycle motor. To obtain the proper speed, if the blower is belted directly with motor, I will have to use a 26-in., cast-iron pulley on the motor. Will this make a satisfactory drive, or would it be better to use a jackshaft to secure the desired blower speed? In this case I could use a smaller motor pulley.

Toledo, Ohio. F. H.

Why Does This Commutator Wear Out of Round?

The life of a new commutator on one of our 3-hp., 230-volt, d.c., 1,150-r.p.m.. style SK, Westinghouse motors is very short. This motor, which is belted to a suction fan, is located in a room where lead is melted and cast into bars. In an attempt to overcome our trouble we have tried different brushes, undercutting the commutator, and used good armatures from other machines, but about every three months the commutator becomes egg-shaped. Is it the acid or gas fumes, or something else that is causing the trouble? I shall be grateful for any information that readers can give me.

Chicago, Ill. F. J. C.

Checking Condition of Elevator Cables

We are using the ordinary 6-19 cables on most of our elevators and I wish readers would give me some suggestions on inspecting them for condition. Can our maintenance men determine when these cables need to be replaced by counting the broken strands? If not, what other methods or tests can we employ that will safely determine this point? I shall appreciate any help from readers.

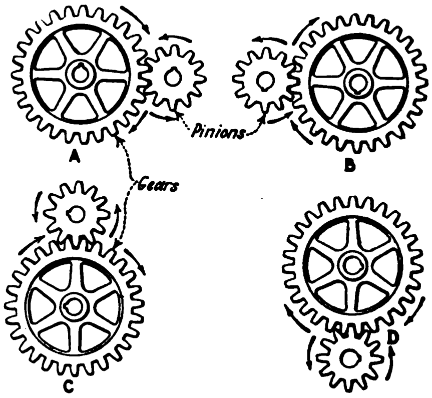
Auburn, N. Y. H. W. J.

ANSWERS

Received to Questions Asked

Location of Motor Pinion

Is there a preferred location of the motor pinion with respect to the driven gear? The accompanying diagram shows four different drive arrangements, one having the motor pinion on top of the driven gear, another with the pinion at the bottom, and others with the pinion on either side of the gear. The direction



of rotation of the gear and pinion is indicated by the arrows. Which of these locations is preferred from the standpoint of stress on the motor frame and on the foundation bolts, lubrication of gear and pinion, and ease of maintenance and inspection? Are they all equally good? I should like to have some of our readers discuss this question, and give me the benefit of an experience they may have had with such a problem.

Landgraff, W. Va. U. J. S.

REFERRING to U. J. S.'s question, a great deal of fine-haired theory could be spun on making the gear thrust balance the weight of the armature, arranging the thrust of the gear to push the motor down on the base instead of lifting it, and so on. However, I believe the most important consideration is to so locate the motor that it will have as solid a foundation as possible; that is, have the minimum of shimming or other construction work between it and the floor, and let the relative positions of the gears come where they will.

As most motor bearings are amply proportioned, they should withstand any load that the motor will subject them to in any direction, so long as the bearings are kept oiled, the rings kept free and the gearing receives proper lubrication.

It might at times be easier to inspect a pinion set above the gear, but the additional trouble of looking at it below the gear will be amply worth all it costs, as such a position lessens vibration; vibration is often the cause of wear and damage to both motor and gear drive.

It is impossible to stress too strongly the necessity of eliminating vibration, either for gear drives or other machinery, as vibration often pounds out the bearings, bearing bolts and grouting. Also, trouble is frequently caused in unexpected places by vibration, with the result that, under such conditions, you are always wondering what is going to break loose next.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

ANSWERING U. J. S.'s question, the location of the motor pinion does not make much difference because the motor can often be located in any of the positions illustrated. The arrangement shown at *B* in his sketch is preferable, assuming, of course, that the motor is mounted with its feet down. With this arrangement all the pressure on the bearing is downward, and there is practically no strain on the foundation bolts, which is a desirable condition.

If the motor is mounted on the wall or ceiling, the same principle should be borne in mind; that is arrange the gearing so that the pressure will be exerted in the direction of the best support. GUY H. WINTERSTEEN.
Cleveland, Ohio.

REPLYING to U. J. S.'s question, one must sometimes be governed by local conditions and his own personal experience when locating motor pinions. For instance, there is little to recommend the arrangement shown in diagram *A* of this sketch, unless the gear and pinion were enclosed in an oil-tight gear case. In this instance only would it rank equal with arrangement *B*, and possibly at times it may even be better, for the reason that chips and other foreign matter would be less likely to be carried between the teeth, if they fell to bottom of the gear case. The arrangement at *A* might also have a tendency to lubricate the gear bearings better than in the case of the arrangement shown at *B*.

Generally, the arrangement at *B* is to be preferred over that at *A*, and over those shown at *C* and *D*, in the case of heavy drives. At *B* the accessibility of the motor frame will allow the gears to be realigned for wear without shimming. With the rotation as shown at *B*, it will be impossible for chips, tools, or other foreign objects to fall and become jammed between the pinion and the gear, in which case the gear would be ruined and the shaft would probably be damaged. If the gear's lower portion is partly in a concrete pit, it is not advisable to have the pit conform to the shape of the gear but rather make the pit rectangular, and in this way eliminate any chance of small objects accumulating in a small clearance space.

The distance between the gear and the bottom of the pit should be four times greater than the maximum openings at the sides. Such a pit will prevent tools and other material from finding their way into a position that might allow them to become wedged under the gears. A steel trap door should be left near the center of the pit, so that it can be cleaned out occasionally. The principal disadvantage of this arrangement is that more floor space is required when a pit is provided.

An arrangement similar to that at diagram *C* is limited to light or medium drives, under usual conditions. The advantage of this arrangement is that the gears and bearings are easy to inspect, the strain on the motor frame is less than with any of the drives shown at *A*, *B*, *C*, and *D*, the motor is kept away from grease and oil drippings, and the lubricant in the motor bearings is not likely to become polluted by gear case contents, as might be the case in *D*, if it were fully enclosed. The motor cannot only be shimmed up, but shims can be removed to allow for wear on open or semi-open drives. In addition the motor can easily be removed for repairs. Little floor space is required and the gears can be enclosed and kept well lubricated. The principal disadvantage of the arrangement at *C* is that with medium heavy drives, especially, a substantial motor support of reinforced concrete is usually required, constructed in a pyramid shape, the bottom of which would be some distance under the floor. In the case of larger motors, the height at which it must be mounted above the floor causes excessive floor vibration in some cases, unless the driven shaft is in a pit under the floor level.

The nature of the work to be performed is of major importance when considering the arrangement shown at *D*. On many types of machines the motor must be below the work or to one side of it, because of possible oil leaks. On shears and similar machines, this arrangement is used to provide a more convenient location with respect to the work table. There are some disadvantages with arrangement *D*, however, for when the motor is placed under the driven shaft, it is harder to make inspections and to clean the motor as it usually needs cleaning more often, due to grease, oil, chips and other foreign matter that may fall from above. If the motor is placed a little to one side of the large gear, the drive is easier to inspect but occupies more floor space and is likely to become a stumbling block.

Without doubt, the position of the motor shown at *D* will result in slightly increased bearing wear as compared with the other arrangements, as well as pollution of motor bearing lubricant, if the gears run in oil or grease in a gear case. A. FIESS.
Tampa, Fla.

Testing Fuses to Prevent Motors Running Single-Phase

We have a large number of three-phase induction motors that are protected by individual fuses placed near each motor. Also, the different branch circuits feeding several motors are protected by fuses. To insure that the motors do not operate single-phase, frequent tests are made of the fuses. Is it sufficient to test the fuses by temporarily connecting a lamp of suitable voltage across the ends of each individual fuse? Will a lamp test across the phase wires ahead of or after the fuses give a positive indication? Will connecting the lamp ahead of one fuse and behind the adjacent fuse give a reliable indication? I should like to have some of the readers discuss these questions for me and point out which is the best method to use for testing under the conditions described and also tell how to interpret the different indications obtained from the lamp.
Newark, N. J. W. S.

ANSWERING W. S.'s question, he could use a voltmeter, and if any of the phases are below normal voltage, he can rest assured that there is a fuse blown. In some cases a fuse at the main line (service entrance) switch may have blown and with several motors running a small motor can be started without detecting the blown fuse; so if a lamp is used at this time to test the fuses the slight drop in voltage would not be noticed.

In case that only a lamp is available for testing and it is suspected that a main fuse has blown, try to start the largest motor on the job, and if it refuses to start, the chances are that a fuse has blown. In order to locate the faulty fuse start at the entrance switch after opening it, so as to disconnect all of the load, and test the fuses on the various circuits in the order that you come to them until the faulty fuse is located. While testing the fuses be certain that the motors are shut down so that no current can circulate from one phase to another. H. J. ACHEE.
District Line Supt.,
Southwest Light & Power Co.
Elk City, Okla.

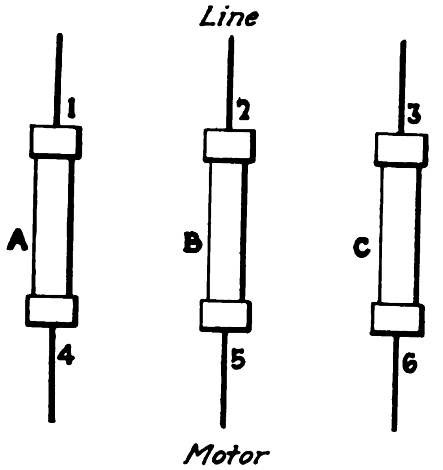
I WILL answer W. S.'s question by telling how 4,041, three-phase, 220-volt loom motors, each with its own switch and cut-out, are taken care of.

We have found that test lamps connected on the load side of the fuses, when the motor is stopped, give the best results. If the motor is running with one fuse gone, the dim light across the open phase is often mistaken for the full brilliancy of the lamp, but if the fuses are tested when the motor is stopped, then a full *out* or *on* of the lights cannot be mistaken.

In testing branch circuits which supply several motors one must be certain all of the motors are shut down before beginning the lamp test because if a motor is running while testing the fuses, the transformer action of the motor will light the lamp to about half brilliancy on the open phase.

By connecting one of the lamp terminals to the line side of one fuse and the other terminal to the motor side of another fuse it is possible to tell which one of a set of fuses is blown when the motor is stopped, for a full light then positively indicates which fuse is faulty. An operator can often detect faulty fuses or an open circuit in the supply line by the way a large motor starts.
Marblehead, Mass. HAROLD H. STEELE.

IN ORDER to obtain specific information in answer to W.S.'s question, I ran a test with a three-phase, 5-hp., 220-volt, 60-cycle induction motor. The terminals of the fuses will be referred to as *1*, *2*, and *3* respectively on the



This shows the points across which the voltage was measured to detect a blown fuse in a three-phase circuit supplying a motor.

line side of the fuses and as *4*, *5*, and *6* on the motor side.

When the motor was not running, the line voltage was 220.5 volts between points *1* and *2*; 221.5 volts between points *2* and *3*; and, 220 volts between points *1* and *3*. While the motor was running, the line voltage was 220 volts between points *1* and *2*; 220.5 volts between *2* and *3*; and, 219.8 volts between *1* and *3*. After removing one fuse from phase *A*, the voltage was 196.5 between points *4* and 5, 218 volts between *5* and *6*, and, 194-198 (variable) volts between *4* and *6*. The voltage to ground while the motor was running or idle was 119 volts on all phases. After the fuse was removed from phase *A*, the voltage between point *4* and ground was 89 volts, between point *5* and ground, 108 volts, and between point *6* and ground, 102 volts. The variation in voltage between ground and points *4*, *5*, and *6* may have been due to using a temporary ground. The voltage between points *1* and *4*, *2* and *5*, and *3* and *6* was zero until one fuse was removed from phase *A*, thus causing a voltage drop of 22 volts between points *1* and *4*. A test lamp placed across these two points burned at approximately one-quarter brilliancy and drew 192 mil.-amp. The normal current of this lamp at full brilliancy is 442 mil.-amp. The lamp used was a 115-volt, 50-watt, mill-type Westinghouse lamp. A carbon lamp was then substituted for the tungsten filament lamp, its rating being 16 cp. at 115 volts. When this lamp was used, the filament became quite red, but not as brilliant as the tungsten lamp. This carbon lamp drew 120 mil.-amp., while its normal current was found to be 622 mil.-amp. on a 116-volt lighting circuit.

I believe that 15 volts is sufficient to force enough current through a lamp filament to get at least a test indication, particularly if a tungsten or a tantalum light were used, for these two lamps show only a small resistance when cold, but a high resistance when heated. The resistance of the carbon filament lamp is higher when cold than when hot.

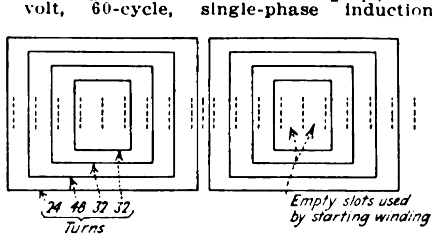
My test was conducted on a motor running practically without load, and as the counter-electromotive force drops as the load increases, the difference between the two voltages increases; consequently, an increase of load on the motor would tend to increase the brilliancy of the test lamp while spanning the blown fuse.

Personally, I much prefer a thermal cut-out, of which there are a number of good makes on the market, as a means of protecting a motor against single-phase operation. I feel that such devices are a profitable investment for those who are having trouble with their three-phase motors running single phase. E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Method of Determining Chord Factor

I shall appreciate receiving any information from readers concerning satisfactory methods of finding the chord factor for the following winding. The winding is on the stator of a ½-hp., 110-volt, 60-cycle, single-phase induction



motor. The stator has 36 slots and four poles and is arranged with a starting winding. The main winding is connected as a whole coil, concentric, as is shown in the accompanying diagram, which shows two pole groups.
Milwaukee, Wis. J. M.

ANSWERING J. M., finding the chord factor of a single-phase motor is quite similar to finding the chord factor of a three-phase motor winding.

Chord factor is defined as the sine of one-half the angle spanned by the coil. In the single-phase winding each pole has several coils which span a different number of slots and for that reason each coil will have a different chord factor. In the three-phase motor, each coil spans the same number of slots and consequently each coil will have the same chord factor.

To see that the above is true, it is necessary to remember that the coil in the center of the pole will not be as effective as if it were in the position of the outside coil. The chord factor multiplied by the actual number of turns will give the number of turns which would produce the same results if the winding were not chorded. The above statement applies only for the turns in series.

In a four-pole motor each coil must span 90 space degrees. Space degrees cannot be used for determining the chord factor because only in a two-pole machine is the number of space degrees equal to the electrical degrees. Each pole will then have 180 electrical degrees. The sine of one-half of 180 deg. or 90 deg. is unity. Also, the chord factor of the outside coil of each pole is unity.

The chord factor has already been found for the outside coil. The second coil or the one with 48 turns will be considered next. Since the motor has 36 slots and four poles, each pole will be the equivalent of 36 ÷ 4, or 9 slots. These nine slots will be equal to 180 electrical degrees. Each slot will be removed 20 deg. from the one next to it. The coil under consideration then will span 7 x 20 or 140 electrical degrees. The chord factor will be the sine of 140 ÷ 2 = 70 deg., or 0.94.

These relations are shown in the accompanying table. The last column gives the product of the actual number of turns times the chord factor. It is interesting to note that the inside coil has 32 turns and yet has the effect of only 16, if the 16 were wound full pitch.

Since the other three poles are identical with the one that was considered, it is not necessary to make the calculations over again. The figures at the bottom of the last two columns show the effect of chording.

CHAS. F. CAMERON
Rock Springs, Wyoming.

THE method of finding the chord factor of J. M.'s motor involves considerable figuring, first, because the slots do not have the same number of wires in them, and, second, because some coils are half-coils and some are whole coils.

The motor has four poles and 36 slots; so one pole contains nine slots. Since two poles represent 360 electrical degrees and 2 x 9 or 18 slots represent 360 electrical degrees, one slot equals 360 ÷ 18, or 20 electrical degrees.

To find the factor for part 1 use the formula given in Dudley's, "Connecting Induction Motors." The chord factor is the sine of one-half the angle in electrical degrees that the coil spans, or sine of 60 deg. ÷ 2 = 30 deg. A table gives the sine of a 30-deg. angle

Chord Factor Data for Single-Phase Motor

No. of Coil	Coil Spans	Coil Span ÷2	Chord Factor or Sine	Number of Turns	Turns × Chord Factor
1	180	90	1.0	24	24.0
2	140	70	0.940	48	45.12
3	100	50	0.766	32	24.51
4	60	30	0.5	32	16.0

as 0.50. Therefore, part 1 is only 50 per cent as effective as it would be if it were full pitch. So credit part 1 with 50 per cent of 32 turns, or 16 turns.

Part 2 spans five slots or $5 \times 20 =$ 100 electrical degrees. Proceeding as with the calculations for part 1, the table gives the sine of one-half of a 100-deg. angle as 0.766. Then part 2 can be credited with 0.766×32, or 24.5 turns at full pitch.

With part 3, proceed as with parts 1 and 2. The angle spanned in electrical degrees is 140. The sine of half of 140 deg. is 0.9397, thus crediting part 3 with 0.9397×48, or 45 turns at full pitch.

Part 4 is already full pitch; so this part can be credited for the full number of turns, which is 24. Adding the credits, $16 + 24.5 + 45 + 24 = 109.5$. The actual turns are $32 + 32 + 48 + 24$, or 136.

The chord factor sought is $109.5 \div 136 = 0.805$. The distribution factor will be about 0.87 and the winding factor 0.71. CLAUDE D. MARTIN.
Fort Dodge, Iowa.

IN ANSWER to question asked by J.M., I would say that the chord factor, K_2, is the sine of one-half the angle spanned by a coil, in electrical degrees. In case the coils do not all span the same angle, K_2 may be used to represent the sine of one-half the average electrical degree spanned.

In the present case, one pole spans 180 deg. Inasmuch as there are 9 slots per pole, 180 deg. $\div$ 9 = 20 deg. per slot. The largest coil spans 180 deg., the second coil 140 deg., the third 100 deg., and the fourth coil spans 60 deg., or an average span of 120 degrees. Then $K_2 = \sin(120 \div 2) = 0.866$. Generally, this method of finding the value of K_2 is close enough for most practical purposes.
Murphy, Idaho. ALEX BRENNER, JR.

ANSWERING J. M., I have used with good results the following methods for determining the chord factor.

Chord factor is determined by finding the sine of one-half the angle in electrical degrees which the coil spans. The number of slots divided by the number of poles will equal the number of slots per pole which amount represents 180 electrical degrees. Then, 180 deg. divided by the number of slots per pole will give the number of degrees per slot. The number of degrees per slot multiplied by the number of slots spanned will give the number of degrees spanned. This result divided by two will be the number of degrees, the sine of which is the chord factor and must be found by consulting a table of trigonometric functions.

In J. M's case the pitch will be the average pitch. The spans are 1-10, 2-9, 3-8, and 4-7. Now, since nine slots are spanned in the 1-10 span, seven in the 2-9 span, five in the 3-8 span, and three in the 4-7 span, it is obvious that the average of nine, seven, five, and three equals six. Therefore, the average pitch is 6/9 or 66.6 per cent.

Applying the above formula to the problem: 36 (slots) $\div$ 4 (poles) = 9, Now 180 deg. $\div$ 9 = 20 deg. per slot; 20 deg. $\times$ 6, the average span, equals 120 deg. $120 \div 2 = 60$ deg. The sine of 60 deg. = 0.866, which is the pitch constant or chord factor.

After noting a variety of motors, I have plotted a curve from which a few constants have been taken, as shown in the accompanying table, that will eliminate the above calculations.

Slot Pitches and Equivalent Chord Factors

Slot Pitch	Per Cent Pitch	Chord Factor (K_2)
6/6	100	1.00
5/6	83.3	.966
4/5	80	.951
3/4	75	.924
2/3	66.6	.866
1/2	50	.707

It will be noted from this table that 6/9 is the average pitch and 6/9 equals 66.6 per cent, which pitch indicates a chord factor of 0.866. H. KAELIN.
Kaelin & Beer Electric Co.,
Los Angeles, Calif.

Will This Generator Operate Satisfactorily at Increased Speed?

We have a Westinghouse, Type C, 50-hp., alternating-current motor having a full-load speed of 850 r.p.m., which we plan to use in driving a General Electric direct-current 55-hp., 725-r.p.m. 110-volt generator. We would like to couple these two units directly together instead of making a belt-driven unit. This would necessitate running the 725-r.p.m. generator at a speed of 850 r.p.m., or an increase of 17 per cent in speed. I should like to learn from readers whether or not this generator will operate satisfactorily at this speed, and also whether the increased voltage delivered by the generator can be reduced in any way so as to obtain the original voltage generated at 725 r.p.m.
Hartford, Conn. H. V. D.

IN REPLY to H. V. D., if the armature is securely banded so that the extra centrifugal force exerted on it will not cause the coils to raise, the higher driving speed will cause no trouble.

The additional voltage can be easily taken car of by using a rheostat with a higher ohmic resistance. The additional voltage would require a rheostat of approximately twice the ohmic resistance that is needed with the lower voltage, for the fields on a generator are designed for 20 per cent less resistance than on a motor of the same voltage rating. This is done to allow for regulation of the voltage on the generator.

If there are available two rheostats of the same capacity, connect the two rheostats in series with the shunt fields; then cut in all the resistance in one rheostat and do the regulating with the other one. NICHOLAS J. WEISS.
West New York, N. J.

IN REPLY to the inquiry by H. V. D., I would say that if these machines are connected direct, the generator will give approximately 140 volts.

If H. V. D. inserts the proper amount of resistance in the shunt field circuit of the generator in addition to the field rheostat, he will be able to get the proper voltage regulation, providing the commutation is good. If it is not, the arrangement he proposes is not practicable because the generator will always be a source of trouble due to poor commutation caused by the weakening of the shunt field on account of the resistance required to get the desired voltage regulation. This is about the only way that the original voltage can be maintained on this machine unless it is rewound to suit the change in speed. JOHN COAN.
Chief Electrician,
Rocky Mountain Fuel Co.,
Lafayette, Colo.

REPLYING to H. V. D.'s inquiry, the increase in voltage due to the increase in speed can be reduced by cutting in a little more resistance with the generator field rheostat.

In case this machine, when operating at 725 r.p.m., requires that the rheostat be two-thirds cut out, the rheostat should be sufficient to take care of the greater field strength caused by the higher speed, but if only a few steps of the rheostat are cut out, the voltage will be too high while running the generator at 850 r.p.m., for the rheostat would then have insufficient resistance.

To overcome the lack of resistance, set the rheostat about half way in and insert extra resistance in series with the rheostat until the desired voltage is obtained. This method will provide an excellent adjustment on the rheostat to take care of the variations in the load.

The increase in speed should not have any effect on the machine, as the design is ample to take care of the additional centrifugal force in the armature.

In case H. V. D. has around the plant an additional rheostat of about the same size and design as the one used with the generator, I would advise installing the two in series, and then practically any adjustments can be made to take care of the higher voltage caused by the change in speed.

I had an experience of this kind several years ago, where we increased the speed 25 per cent, and operation was perfectly satisfactory. We installed another rheostat of the same size and capacity in series with the old one and were able to regulate the voltage of the machine at the new speed just as easily as was possible at the former speed.
Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

THE answer to H. V. D.'s question can best be given only by the manufacturer's design department.

It is usually quite safe to operate a motor or generator at 10 per cent above its normal rated speed. On this assumption it would be safe to operate the generator under consideration at about 800 r.p.m., but an increase to 850 r.p.m. would be about 17 per cent above normal, and although the generator would undoubtedly stand this increase for short periods, continuous operation

at this speed should not be carried out without consulting the manufacturer of the generator, for certain designs have definite operating limits.

Just exactly how the increase in speed will affect the voltage is not certain without knowing more about the design of the generator. In general, the voltage will increase in direct proportion to the speed for a certain fixed condition, and it is quite possible that the present field rheostat will take care of the increase in voltage. In any event, additional resistance can be added in the field circuit either as a fixed unit or through a change in the field rheostat, as can be readily determined by trial.

C. OTTO VON DANNENBERG.
Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

Trouble with Storage Battery Charging Generator

We are having considerable trouble due to the reversal of polarity on a 50-kw., 120-volt, interpole generator which is used to charge storage batteries on vehicles. The machines were tested for grounds by means of a Megger and a heavy leakage to ground through the acid-soaked benches in the battery charging department was discovered. Having remedied this, the generator was started and immediately the voltmeter read backwards with no load on the machine. We checked the leads from the machine, but they were of such size and so taped together that it would be impossible to reverse them by mistake. We tried to re-excite the field, but could not; so the leads were reconnected so as to reverse them at the generator and not disturb anything at the switchboard. The generator worked satisfactorily for about three days, when the polarity again reversed itself. We reversed the generator leads to their original position and since then the machine has been operating satisfactorily. I do not know what caused this reversal of polarity and should like to have readers give me their suggestions.
Sacramento, Calif. J. T.

IN ANSWER to J. T., the cause of the trouble could be due to the compound winding being in opposition to the shunt field and thus overcoming the shunt field when it is weakened by the field rheostat. If this is the case, reversing the compound field leads will correct the trouble.

Then again, if this generator is working in parallel with other machines that are compound wound, there should be an equalizer connection, otherwise these other generators many cause J. T.'s generator to reverse its polarity.

District Line Supt. H. J. ACHEE.
Southwest Light & Pow r Co.,
Elk City, Okla.

Lubricating Ball and Roller Bearings

I wisk to know h w thin an oil can be satisfactorily used to lubricate ball and roller bearings used in motors. Do readers prefer the use of grease for these applications and if so, why? What are the desirable characteristics of oils and greases that are intended for use on the roller bearings and ball bearings used in motors?
Youngstown, Ohio. E. L.

IN CONNECTION with the question asked by E. L., there seems to be quite a number of plants that are now testing out various methods of lubrication. My personal opinion is that for general purpose work it is better to use grease for lubrication. The grease should ordinarily be of a consistency slightly harder than vaseline, so that it will maintain its body and not run off the metal surfaces too freely, and not become solid or dry.

It seems to me that the theory of correct lubrication involves the use of a thin film of lubricant between friction-developing surfaces, and some people claim that under favorable conditions an almost imperceptible film of lubricant is sufficient.

The use of oil provides this film during the period of motion, but after motion has been stopped for some time, the oil falls to the bottom of the oil well and leaves dry bearing surfaces. It is conceded that some oil will remain as a thin film on the shaft, but the amount that remains is usually very small and often insufficient to prevent rusting.

It is generally difficult to adopt an ideal lubricant for all the motors in a plant because a motor may be in a dry or moist location, surrounded by air that is clean or dirty, designed with large or small bearing surfaces, and operate with its bearings cold, at normal temperature, or hot. I would recommend that several different grades of lubricants, my preference is grease, be tried out on the various jobs until each machine has had the proper kind of lubricant selected for it.

NATHANIEL W. BLANCHARD.
Inwood, L. I.

IN ANSWER to E. L.'s question, and commenting on a previous answer to this question, I wish to advise that the makers of anti-friction bearings especially discourage the use of graphite as it is considered very injurious to ball and roller bearings.

As a rule, a high-grade mineral grease of light or medium consistency has been found most satisfactory for general-purpose electric motors using ball bearings. Such a grease will not leak past the average seal and will prevent the entrance of dirt into the bearings. Very high speed motors require different treatment and usually employ a light oil fed in small quantities.

H. W. HOLDSWORTH.
Engineering Dept.,
The New Department Mfg. Co.,
Bristol, Conn.

IN REGARD to the question asked by E. L., a mineral oil with a viscosity of 100-200 sec. Saybolt at 100 deg. F. should be used for bearings cn small high-speed motors. With roller bearings it is best to use a mineral oil up to 750 sec. Saybolt at 100 deg. F.

A straight petroleum grease should be used in dirty locations for it seals the bearings against dust, dirt and moisture, and it is easier to retain grease than oil in a non-oil-tight bearing. However, grease should not be used for roller bearings revolving over 1,200 r.p.m.

The oil used should not contain any compound of animal or vegetable oil, should be neither acid nor alkali, and should not readily absorb moisture or saponify.

For ball bearings in clean locations, use oil, but in dusty or dirty locations, use light grease, and for roller bearings use a heavy-bodied mineral oil or a medium grease. W. E. WARNER.
Shefford, Bedfordshire, England.

Trouble from Cable Overheating

When connecting up a turbo-generator rated at 480 volts, three phase, 60 cycles, 3,000 amp., I used five 1,000,000-circ.mil, rubber-covered cables in parallel. According to the wire table each cable should carry 650 amp.; therefore, the six cables in parallel should carry a total of 3,900 amp. The total of 18 cables for the three phases run in six conduits, each conduit carrying three cables, one from each phase. With this arrangement the cables heated and I fould it necessary to add a seventh cable to each phase. This should give a total carrying capacity of 4,550 amp. which is 50 per cent more than the rating of the turbo-generator, 3,000 amp. With the seven cables operating in parallel on each phase there is no heating and the cables carry satisfactorily an average load of 3,000 amp. with peaks running somewhat over 3,500 amp. Can any reader suggest causes why the first installation of cables should overheat? Could it be due to inductive effects? If so, how could I go about correcting this trouble?
Bellingham, Wash. E. M. D.

THE trouble experienced by E.M.D. is probably due to a great extent to the lack of suitable radiating surface, which was caused by too great a concentration of the cables. Without having a layout of the conduit arrangement, it is impossible to tell just how close the cables are run.

A rating of 650 amp. for a 1,000,000-circ.mil cable applies strictly to a single cable. The allowable carrying capacity must be modified when three cables are carried in one conduit and when there are adjacent conduits which would further tend to reduce the heat radiation. Problems of this nature are often encountered in underground conduit work and they require special treatment and recommendations, depending upon the arrangement of the cables, as well as the average temperature surrounding the conduits.

For instance, published data by a cable manufacturer states that with a cable capacity of 100 per cent at 75 deg. F., the capacity of the cable will be reduced practically 50 per cent when the temperature is 130 deg. F. Assuming that a single conductor cable has a 100 per cent capacity, a three-conductor cable will have the conductor capacity reduced 75 per cent. In the present case, using three single conductors in a conduit will probably reduce the capacity of each conductor to approximately 85 per cent of its normal capacity, or 550 amp., although this value will be further reduced by the concentration of 21 cables in a small area, thus interfering with the radiation so that it is practically impossible to tell in this case, except by actual experience, just what size cables to use.

Certain published data state that where more than two cables are run in adjacent ducts the capacity per conductor is reduced 54 per cent when there are 12 cables. While this statement applies to underground construction, it indicates clearly the reduction in a conductor's capacity due to limited radiation. Referring specifically to this case under consideration, loads requiring the use of more than one 1,000,000-circ.mil cable per leg should, if possible, be carried by means of copper bars, when it is at all possible to do so. Also, the conductor should be installed bare, for this low voltage, if the conditions permit. The advantage of a bar conductor over round cable

is obvious when it is realized that a bar 4 in. by ¼ in. has a perimeter of 8½ in., while a round cable of equivalent circular mil capacity, say 1,250,000 circ.mils, has a circumference of only 4.03 in.; in other words the bar has twice the radiating surface per foot of length and hence has considerably greater carrying capacity. A manufacturing concern that has investigated the transmission of heavy alternating currents, recommends that for a 60-cycle, 3,000-amp. current, three 4-in. x ¼-in. bar conductors be used and arranged with the two in the top row ¼ in. apart, and the third bar 2 in. below the other two. It is obvious, however, that without knowing the exact operating conditions referred to by E.M.D. only a general answer can be given.

C. OTTO VON DANNENBERG.
Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

IN REPLY to E.M.D., I assume that he was using six cables of 1,000,000-circ.mil area and increased the number of cables per phase from six to seven as a means of overcoming the excessive heating of the cables, which would likely cause serious trouble.

I do not see any reason to believe that the heating was due to induction, as the arrangement of the cables would preclude this possibility, but feel that it was most likely due to the carrying of so many large cables in one conduit, with no way of dissipating the heat fast enough to keep the cable temperatures down to normal.

It does seem that cables, grouped in a manner to prevent induction, should carry the required current, if due allowance were made to take care of the radiation, or if the cables were connected directly to the buses without conduit.

The radiation of heat from cables becomes a serious consideration with cables of heavy current capacity. As an illustration of this point, experiments show that the carrying capacity of cables so grouped is from 4 to 25 per cent less than the single conductor capacities when amply ventilated. The corner cables in a square conduit will carry the most current for same temperature rise as other cables in the group.

I would blame the trouble with the cables on the small amount of radiation, although there are a number of other considerations of less consequence that enter into the problem and must be given proper attention.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.,
Aurora, Ill.

REPLYING to E.M.D., although it is true that the wire table gives 650 amp. as the carrying capacity of a 1,000,000-circ.mil cable, this applies to only one cable. When several cables are used in parallel, their ratings are much different on account of induction, cooling space, location and method of installation, as open wiring, or arrangement in conduit, or fiber and tile ducts, etc.

E.M.D. says that there were originally six conduits, three cables per conduit, six cables per phase in the first installation, and it was found necessary to add another cable to each phase, making a total of seven cables per phase.

The layout of the conduit may be considered fair, if there is a chance for cooling air to enter the ends of the conduit or to come in contact with the conduit elsewhere in the run. The size of the conduit installed has not been given; so I cannot determine the cooling space inside the conduit. The current densities in cables, run as these have been, are unequal and it is doubtful if the cables could be rated at much over 450 amp. each, due to several causes.

Putting all three phases in each conduit is the correct arrangement, and if the cables were run any other way, they would no doubt operate very hot and all metering would be inaccurate. Cables in conduit runs give practically the same current-carrying conditions as busbars on a bus structure. For example, one ¼-in. x 4-in. busbar carries 1,200 amp. safely, while two ¼-in. x 4-in. busbars in parallel carry 2,200 amp., or less than double the capacity of one bar. When four ¼-in. x 4-in. busbars are placed in parallel with a ¼-in. spacing between bars and standard spacing between phases and ground, the capacity is limited to about 3,300 amp., unless forced ventilation is employed.

When conditions permit busbars may be transposed, thus gaining considerable capacity, but this is seldom done due to the complicated bending which would be encountered. After two or more cables or buses are employed in parallel, the ampere-capacity curve drops off very sharply and when as many as 12 cables are used in parallel the total rating is only 50 per cent of the sum of their individual ratings, as indicated in wire tables.

If E.M.D. cares to make a change in the cables, it would be advisable to have a smaller number of conduits, and cables of a larger size. One method that could be used would be to install fiber ducts or tile ducts and use lead-covered cable. If lead-covered cable is used, do not use single-conductor cables, but use three-conductor cables.

These will then be very large and difficult to handle, but once installed correctly the trouble is remedied and can be forgotten as far as the cable is concerned. In the event that lead cables are used, suitable non-magnetic cable potheads will be required. I might suggest the use of a three-conductor, 1,500,000-circ.mil lead-covered, paper-insulated cable. In this case it would be necessary to use four of these cables in order to obtain the necessary carrying capacity.

Cables laid in fiber or tile duct systems are rated in the following manner: Assuming that the capacity of one of the above-mentioned cables installed in a duct system is 898 amp., if two cables are used together in the system the capacity of each cable will be reduced to 90 per cent, or the total rating of the two cables will be reduced 10 per cent.

When four cables are installed, as would be necessary in this case, the capacity of the four cables would be approximately 75 per cent of the total rating of each cable when used singly, or $898 \times 4 \times 0.75 = 2,694$. These figures are based on cables operating at only 65 deg. F., which is cool. These cables at a temperature of 95 to 100 deg. F. will carry from 3,200 to 3,400 amp. safely, and 100 deg. F. is not too warm. If the expense of lead cable is not warranted, it would be advisable to install two 6-in. conduits. In these two conduits install two 2,000,000-circ.mil r.c. cables per leg, making a total of six 2,000,000-circ.mil cables, three cables in each conduit, with the three phases represented in each conduit. Two 2,000,000-circ.mil cables will easily carry 3,000 amp. and 3,500 amp. can be carried for peak loads of only an hour or so.

If E.M.D. had given the length of the cable runs and also a sketch showing their location, it might have been possible to rearrange the cables in such a manner as to further increase their capacity and permit the use of the present cables, but with the information furnished, I would recommend either one of the two above-mentioned layouts, in preference to trying to use the present cables in some other way. Cable installations taking care of heavy loads present a proposition that is difficult to handle, besides requiring much experience and an exact knowledge of each installation regarding the location of the cables and other important factors.

I would like to hear from him personally or through the columns of INDUSTRIAL ENGINEER concerning the methods used in the final installation and the results obtained.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.
Donnacona, Que., Can.

Soldering Springs in Ammeters

Will some reader kindly tell me the best method of procedure in soldering the springs in electrical instruments of delicate construction, such as ammeters, voltmeters, wattmeters, and the like? These springs are usually made of phosphor bronze, although some other materials are sometimes used. I should like to know what mixture of solder should be used and also what kind of flux is best adapted to the work. Any other hints that readers may give me in regard to the method of soldering will be very much appreciated.

New York, N. Y. L. A.

REPLYING to L. A.'s inquiry phosphor-bronze springs can be successfuly soldered, with the ordinary jewelers' silver solder and flux, but almost invariably the soldering will affect the temper of the spring to such an extent that afterwards it is impossible to recalibrate the instrument with any degree of accuracy. The method of soldering these springs employed by the manufacturers seems to be well guarded; so I have found it cheaper and more satisfactory to return such instruments to their maker when repairs on them are necessary. Nothing is to be gained, and much may be lost, by trying to do a job for which the necessary experience or facilities are lacking.

G. H. WINTERSTEEN.
Cleveland, Ohio.

Difference Between Star and Delta-Connected Motor Windings

Can some reader tell me if there is any difference in the starting current, torque, power factor, and efficiency of a star-connected motor winding as compared to a delta-connected winding. In each case the motors under consideration are of the same make, horsepower, and number of coils. Why are some motors star-connected while others are delta-connected? Does either form of connection have advantages over the other? I shall greatly appreciate any information that readers may give me on this subject.
Lethbridge, Alberta, Can. W. T.

IN REPLY to W. T., there are several good points in favor of a star connection, from the construction standpoint only. Some manufacturers prefer a star connection rather than a delta on account of the smaller number of turns required per coil. A delta connection requires 1.73 more turns than a star connection, but the wire required is of a smaller size. The greater number of turns required by the delta connection makes it necessary to allow more space in the slots for insulation, thus leaving less space for the copper itself. For instance, a coil of 30 turns star-connected would not take up as much space with cotton, silk, or enamel insulation as a coil of 50 turns of a smaller wire would require with the same kind of insulation. The coils of the smaller sized wire are less rigid than coils made of wire of a larger size. The price of magnet wire increases as the size of the wire decreases; also, it is more expensive to wind the coils having the larger number of turns.

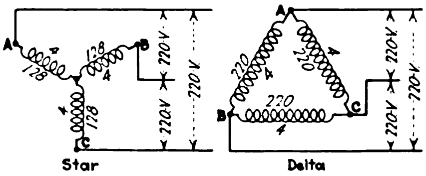
As to torque and starting current, take as an example the two motors mentioned by W. T. The delta-connected motor will have a lower starting torque and a lower starting current than the star-connected motor. No doubt the delta connection will also result in a slightly higher power factor, but it is probably safe to say that the two motors will be about equally efficient. The delta-connected motor may run a little more quietly than the one that is star-connected and perhaps it will have less tendency toward vibration of a mechanical nature.

Now, the star-connected motor will have a higher starting current and a correspondingly higher starting torque due to the higher current. The power factor may be a little lower, but the general efficiency remains about the same as the delta-connected motor. Perhaps the mechanical vibration with the star connection may be greater, hence it may make a little more noise.

So far as operation is concerned, there does not appear to be very much difference between a star-connected and a delta-connected motor, when all points are taken into consideration, and each bad point balanced against a good point of the other type of motor. The main things to look for in the characteristics and operation of induction motors are the starting torque, starting current, power factor and efficiency. Ordinarily a little more or a little less noise makes no difference to the buyer or operator. When considering the star-connected motor from the repairman's or winder's point of view, no doubt a preference will be shown for the star connection, especially if there are very many semi-closed slot motors to be rewound as it takes more time to install coils for a delta connection owing to the larger number of turns. As a rule, in reconnecting old windings to new operating voltages, frequencies and phases, it is easier to change a star connection than a delta. LEE F. DANN.
Chief Electrician,
Dannacona Paper Co., Ltd.,
Donnacona, Que., Can.

TWO motors designed for the same horsepower, one connected star and the other delta, will have practically the same operating characteristics relative to starting current, torque, power factor and efficiency.

By changing a star-connected motor to delta, or a delta-connected motor to a star connection the operation of the motor will be materially affected, if used on the same supply circuit but, if the supply voltage is changed so as to correspond to the new connections, the characteristics of the motor will not be changed.



The general arrangement of coils in star and delta connections is indicated in these diagrams.

A change from a star to a delta connection makes it essential that the size of the wire in the motor coils be large enough to carry the increased line current. This increase in current in a delta-connected motor is 1.73 times the current used when the motor is star-connected, while a change in connections from delta to star reduces the line current used by an amount equal to line current divided by 1.73, and the increase in the operating potential of the motor is 1.73 times the delta-connected operating voltage.

A motor that is star-connected for 173 volts and 100 amp. will operate with the same characteristics when reconnected delta, for operation on 100 volts, and taking 173 amp., but when changed to a delta connection and the motor is operated from the original 173-volt supply circuit, the potential per coil will have been increased 173 per cent. In this case with a potential of 173 volts there would be a tendency to increase the horsepower rating of the motor. This increase in horsepower is not possible with the same amount of iron, the result being that the motor would be more or less overloaded.

Motors as a rule are star-connected, for this arrangement is easier to connect and test, but another very good reason for using the star connection is the possibility of the customer desiring to change the operating voltage. Suppose a motor was purchased with a 220-volt, delta connection. In this case the motor would really be limited to one connection, for a change to a star connection would require a line voltage of 220 $\times$ 1.73 or 380 volts which is not a standard voltage. On the other hand, if this motor were originally star-connected for 220 volts, it could be used if reconnected delta, on a line voltage of 220 $\div$ 1.73 or 128 volts, which is close enough to 110 volts, a standard voltage, for the motor to operate satisfactorily after the change.

The effect of star and delta connections is very often utilized in starting motors, the winding terminals being brought to a triple-pole, double-throw switch which connects the windings in delta for starting and in star for running.

By referring to the accompanying illustration it will be noted that in the star diagram the group voltage is (line voltage $\div \sqrt{3}$) $\div$ 4 = 32 volts, while with the delta connection the group voltage is 220 $\div$ 4 or 55 volts. The ratio of 55 volts to 32 volts being 1.73, the current in the star-connected coils becomes 1.73 times that in the delta-connected coils when the motors are operated on the same line voltage. The star-connected voltage per leg is line voltage $\div$ 1.73 and the current in the star-connected coils is equal to line current. With coils wound for the delta connection, the voltage per leg is line voltage and the current in the coils is line current $\div$ 1.73.
Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.,
Aurora, Ill.

IN ANSWER to W. T., there is practically no difference between the operation of delta- and star-connected motors when the voltage, frequency, horsepower, windage and a few other characteristics are similar. But a motor that is wound for a given voltage and connected star, cannot be reconnected delta and still operate properly on the same voltage, for when a change is made from star to delta, the new voltage is found by dividing the original voltage by 1.73, and the amperage is determined by dividing the former star amperage by 1.73 for the delta amperage.

If there are two motors, as stated, that are of the same make, horsepower, voltage, and number of coils, one connected delta and the other star, there will be 1.73 more turns per coil in the delta-connected motor, but the wire in the coils will have less cross-sectional area in proportion to the ratio of line current $\div$ 1.73. Consequently the copper in coils of either motor will weigh the same.

The question of which connection to use is established by the manufacturer, as one connection or the other usually lends itself to a reduction in manufacturing costs. For instance, if a manufacturer wishes to employ women, the wire of which the coils would have to be made for a given size of motor may be too stiff for them to handle, if the motor were connected star, although the women could probably handle the smaller size of wire required by a delta connection.

There are likewise other occasions when a manufacturer is obliged to use commercial sizes of wire in a given frame, for he can by chording obtain the desired voltage exactly with one connection but he may not be able to do so with the other.
Ft. Dodge, Iowa. CLAUDE D. MARTIN.

Electrical Service

AROUND THE WORKS

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Chart for Finding Physical Properties of Copper Wire

THE accompanying copper wire chart illustrates the wire tables graphically and the regularity of the sizes of wire shows that the tables were designed with a uniform variation when referred to a logarithmic scale. It will be noted that the sizes of wire given in the gage numbers are spaced evenly. The difference between the diameters of No. 29 and No. 30 wire is 1.3 mils, while the difference between the diameters of No. 3/0 and No. 4/0 wire is 50 mils. The reason for the difference in the increment or decrement is that, for all practical purposes, wire with a diameter of 459 mils would serve as well as a wire with a diameter of 460 mils.

It was then decided to make the wire tables with a constant ratio between the areas. This was not a needless complication, but rather a simplification. The user of the American Wire Gage is fortunate because it is the only system that has any scheme of regularity and adheres strictly to that scheme. The three straight lines on each side of the accompanying chart demonstrate conclusively that in the American Wire Gage there is a constant ratio between the area, resistance and weight of one gage number compared with that of another.

To use the chart, trace vertically upward above the desired size of wire to the intersection of that line and the diagonal line marked *Circular Mils Area* and from this intersection trace horizontally to the column with the same marking where the area in circular mils is indicated. To find the pounds per 1,000 ft. continue the vertical tracing until the diagonal line marked *Pounds per 1,000 ft.* is met and read the value given by the horizontal projection in the column marked *Pounds per 1,000 ft.* The ohms per 1,000 ft. is found in the same manner.

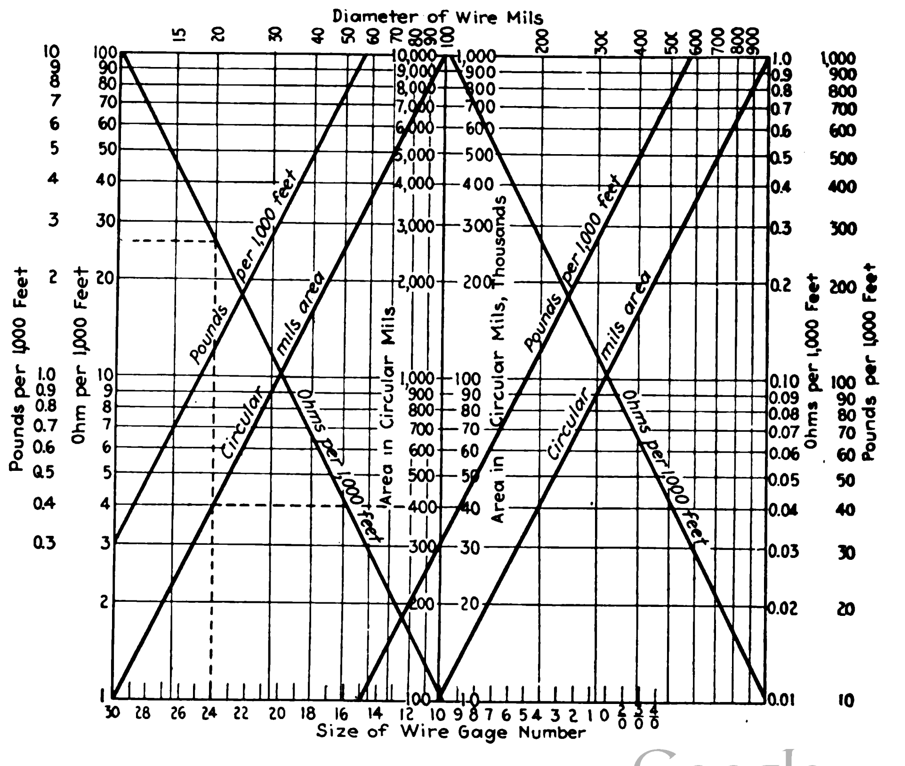
An example will illustrate the above procedure and also demonstrate what degree of accuracy may be expected. Suppose for instance it is desired to find the area, weight and resistance of No. 24 wire. To find the area of the wire, start from the point at the bottom of the chart marked No. 24 gage and trace the dotted line which extends upward in a direction vertical with the bottom of the chart to the diagonal line marked *Circular Mils Area.* From the intersection of these two lines trace horizontally to the column marked *Circular Mils Area* to find area of No. 24 gage wire. By continuing to trace the dotted line upward until it intersects with the diagonal line marked *Pounds per 1,000 ft.*, and further on to the diagonal line marked *Ohms per 1,000 ft.*, the weight and resistance of the wire may be found.

On the parts of the chart marked with the larger graduations, it is evident that the values may be read to the second significant figure, the third being estimated. With the finer graduations, it is necessary to estimate the second significant figure. After a small amount of practice, the chart may be used with confidence and with the knowledge that the figures obtained are only slightly in error. C. F. CAMERON.

Rock Springs, Wyo.

The cross-sectional area, weight and resistance of No. 30 to No. 4/0 copper wire can readily be determined from this chart.

In order to determine the area, weight or resistance of a certain size of copper wire, trace upward from the gage number of a certain size of wire to diagonal line marked *pounds per 1,000 ft., circular mils area, or ohms per 1,000 ft.,* as the case may be, and from the intersection between the line drawn vertically and one of the diagonal lines trace horizontally to the column marked the same as the diagonal that has been intersected by the vertical line.



Use of Potentiometer to Supply Power for Signal Systems

FOR economical reasons, lighting circuits are now frequently used to supply electric current to low-voltage systems in place of the much used wet or dry cell batteries. The increasing use of low-voltage equipment, such as indicators, bell systems, telephones and the like has induced a large organization to utilize potentiometers with 110-volt, d.c. circuits, whenever practical, to supply the desired low voltage.

The simple potentiometer used consists of a correctly designed resistance coil placed across the mains with taps to give the desired voltage. The load characteristic of a potentiometer is similar to the external characteristic of a self-excited, shunt-wound generator; that is, an overload causes a rapid drop in voltage, which may fall to zero. For any particular load, the voltage may be increased by decreasing the total resistance of the potentiometer, or by taking off the load from a higher tap. If a higher tap is used, however, the voltage delivered at no-load is increased. Hence, for economical operation, the balance between the total current consumed and the no-load voltage is the problem of design.

This latter statement may be better understood by referring to Table A. This table gives the calculated performance of a potentiometer having a total

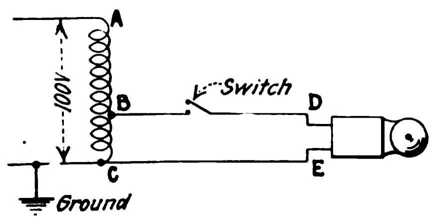


Fig. 1—Typical potentiometer layout for low-voltage signal systems with only a small variation in the current demands.

The direct-current lighting circuit leads are connected to the potentiometer at *A* and *C*, the ground connection being connected to lead *C*. The location of top *B* together with the resistance of coil *AC* is selected in accordance with the lighting voltage and the current requirements of load *DE*.

resistance of 100 ohms and a 20 per cent tap to supply the low-voltage circuit. The potentiometer is connected across a 100-volt supply. The table gives the performance of the potentiometer under different loads.

Referring to Fig. 1, the effective resistance of *BC* and load in parallel = [20 *DE* ÷ (*DE* + 20)]. In this case the resistance *BC* is represented by 20 ohms. The total resistance in ohms across the service line *AC* is [80 + (effective resistance of *BC* and *DE* in parallel)]. In this case 80 ohms represents the resistance between *A* and *B*. The total current in amperes supplied by the service line is 100 ÷ [80 + (effective resistance of *BC* and *DE* in parallel)]. Voltage between *DE* or *BC* = (current through *AB*) × (effective resistance of *DE* and *BC* in parallel). The current through the load = (voltage of *DE*) ÷ (resistance of load).

Table B shows the increase in voltage and current obtained through the same load values when a 20 per cent tap is taken from a 10-ohm coil instead of a 100-ohm coil, as was the case in section A of the table. The maximum output in watts is obtained from the potentiometer when the internal resistance *BC* and the load resistance *DE* are equal. This fact may be often used to advantage as the basis of design.

For example, if current is to be supplied to a two-circuit, electro-mechanical gong fire signal system, supervised by the full operating current of 125 mil.-amp. per circuit, a constant load of 0.25 amp. at 20 volts is required. By Ohm's law the resistance of the external circuit is $R = E \div I$, or $R = 20 \div 0.25 = 80$ ohms. Making use of the maximum output, as explained in the preceding paragraph, fixes the resistance of the *DE-BC* section.

The first column of the table gives the resistance of the load. In Fig. 1 let *DE* represent a load of which the resistance can be varied at will, and *AC* a potentiometer having 100 ohms total resistance with a 20 per cent tap at point *B*. Now, when the resistance of *DE* is 40 ohms, we find that the effective resistance of *BC* and *DE* in parallel, that is, the effective resistance of 20 ohms in parallel with 40 ohms, is equal to $(R_{BC} \times R_{DE}) \div (R_{BC} + R_{DE}) = (20 \times 40) \div (20 + 40) = 800 \div 60 = 13.3$ ohms, as given in the second column, first line. Then the total resistance between points *A* and *C* equals $13.3 + 80 = 93.3$ ohms, as given in the third column. The total current supplied to the potentiometer will be $100 \div 93.3 = 1.07$ amp., as given in the fourth column. To find the voltage supplied to the load, we first determine the voltage drop over *AB*, which is equal to $1.07 \times 80 = 85.6$ volts. Subtracting this from the line voltage we get $100 - 85.6 = 14.4$ volts supplied to load *DE*, as given in the fifth column, first line of table. Then the current input to the load will be the voltage delivered by the potentiometer divided by the load resistance which equals $14.4 \div 40 = 0.36$ amp. as given in the sixth column, first line. Comparing the first and fifth columns, we find that a change in the resistance of the load will cause a large change in voltage delivered to the load.

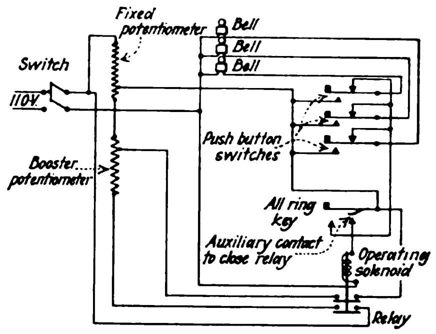


Fig. 2—Using a booster potentiometer to supply intermittent demands for more current.

The fixed or permanently connected potentiometer handles only light loads, such as ringing small bells and the like. When heavier demands for current must be met, the booster potentiometer is cut into the circuit by means of a relay.

As the voltage across *DE* is 20 volts, section *AB* must then absorb the difference between the load and supply voltages, in this case 100 — 20, or 80 volts. But since the resistances of the *BC* and *DE* sections are equal, the current in each leg is 0.25 amp. and the current through the *AB* section is 0.5 amp. which fixes the resistance of *AB* as $R = E \div I$, or $80 \div 0.5 = 160$ ohms, which takes care of the 80 volts between *A* and *B*. It is also desirable to check the no-load voltage obtained when the external load is removed. In this case the resistances of the *AB* and *BC* sections are 160 and 80, respectively, making a combined resistance of 240 ohms between the 100-volt service lines. Since the *BC* section is a third of the full resistance between the service lines, the no-load voltage is 33.3 volts.

The great advantage of potentiometers is most apparent when the external load is intermittent in character, in which case a booster potentiometer may be brought into service by means of a relay and in this way take care of any heavy load during the time for which the load is to be supplied. Booster relays might be used for fire signal systems where the full operating current is not required for supervision, for all-ring, classroom-bell operation in school buildings and for many other uses. Fig. 2 indicates a typical layout for such a system.

Commercial resistances are rated in watts, in which case the current supplied is dissipated as heat or I^2R losses. Generally, commercial resistances are rated 200 watts continuous duty and 500 watts for 20 seconds. The simplest form of resistance for potentiometer use is a bare wire wound on an insulating tube. Adjustment of voltage can be conveniently made by means of a movable slider. In another form of potentiometer permanent taps are brought out from the coil, and the joints, together with all of the coil, are then covered with a vitreous enamel and fired.

Potentiometers may be mounted in the open on a slate switchboard or enclosed in a metal cabinet. If enclosed, asbestos wiring had best be used because a non-ventilated cabinet will often radiate more heat than a ven-

Voltage and Current Characteristics of Potentiometer Under Different Load Conditions

Resistance of Load *DE* in Ohms	Effective Resistance of *VC* and *DE* in Parallel	Total Effective Resistance Between *A* and *C*	Ampere Input to Potentiometer	Volts Applied to Load *DE*	Load, *DE*, in Amperes	Load, *DE*, Watts
A—Total resistance of potentiometer coil AC equals 100 ohms						
40	13.30	93.3	1.07	14.4	0.362	5.17
20	10.00	90.0	1.11	11.1	0.550	6.11
10	6.70	86.7	1.15	7.7	0.780	6.01
5	4.00	84.0	1.19	4.8	0.960	4.61
3	2.60	82.6	1.21	3.2	1.050	3.36
1	0.95	80.9	1.24	1.1	1.200	1.32
B—Total resistance of potentiometer coil AC equals 10 ohms						
40.0	1.90	9.9	10.1	19.2	0.48	9.21
20.0	1.80	9.8	10.2	18.4	0.92	16.9
10.0	1.70	9.7	10.3	17.3	1.73	29.9
5.0	1.40	9.4	10.6	15.0	3.00	45.0
3.0	1.20	9.2	10.9	13.1	4.40	57.6
1.0	0.63	8.6	11.6	7.3	7.30	53.3
0.5	0.40	8.4	11.9	4.8	9.60	46.1

tilated one for the reason that the whole cabinet is raised an equal amount above the ambient temperature and the whole surface is available for heat dissipation and thus localized hot spots are more often avoided. However, each case must be treated individually, and as most potentiometers for this class of work need not radiate more than 50 watts continuously, the usual precautions accorded to electric lamps of similar watt consumption are all that is necessary. LEO S. LOOMIE.
New York, N. Y.

Savings Made in Repairing Water Wheel Casing by Arc Welding

AN ELECTRIC arc welding operation that was recently performed on a water wheel saved the company involved approximately $800 and the job was completed in 11 weeks less time than would have been the case if it had been necessary to wait for a new section of the casing.

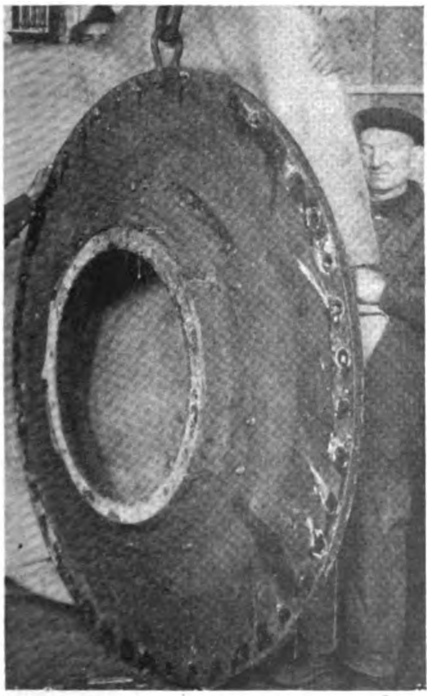
This water wheel casing was badly in need of repair, for the bearing had become worn, thus allowing the wheel to move over and wear away a section of the casing. The worn section was about 10 in. wide by ¾ in. to 1 in. deep around the entire periphery of the casing. In some spots the casing was worn away entirely and in others the parent metal was only $\frac{1}{32}$ in. thick. Some holes up to 1 ft. long had previously been covered by a patch on the outside.

A Westinghouse 200-amp., three-phase, 25-cycle, 550-volt, portable arc welding set was used on this job. The very thin section and the part that was entirely worn away were first spanned by circular hoops made of steel rods. The first rod, ⅝ in. in diameter, was welded to the neck of the casing, another ⅝-in. rod was welded to this one and a ¾-in. rod was welded to the second rod, a space being left between this third rod and the next one, large enough to insert a ⅝-in. rod. After a ½-in. rod was welded to the cast-iron casing, the ⅝-in. rod was inserted in the place left vacant for it, and welded to the rod on each side of it, thus bridging over the weakest part of the casing. The rest of the worn section was then filled in and the surface of the casing ground to a smooth finish by means of a portable grinder.

The striking feature of this job is that it was completed at a cost of approximately $200 and in seven days time, whereas a new casing would have cost $1,000, and could not have been obtained for at least three months.

This worn-out waterwheel casing was repaired by arc welding.

The thinnest places were reinforced by steel rods and then built up to the required level, after which the surface was ground smooth.



Using Test Receptacles in Checking Motor Loads

UNTIL a few years ago motor testing was a problem and tests were made only in a very superficial manner, due primarily to improper testing facilities. Today, as a rule, plants of any appreciable size are fairly well equipped with testing instruments, but frequently no provision is made at the motor or starter to enable the tester to connect his instruments without danger, inconvenience, and a certain loss of motor service.

In our plant 98 per cent of the motors operate at 550 volts, a.c. This is a dangerous voltage, especially around paper mills, where so much moisture is present. Frequent tests are necessary, due to reconstruction or rearrangement of drives and motor changes, for our plan is to keep the motors loaded as close to their ratings as possible. A method of connecting instruments and the necessary transformers was therefore required in order that tests may be made at any time without shutting down the motor even for a very few minutes. With this in view each starter is now equipped with a Square D safety switch. These switches are fitted with test receptacles which are connected in series with the incoming and outgoing leads of the switch. These test receptacles are now utilized in making all tests by plugging in the necessary plug connectors.

Our instruments consist of a triple-range voltmeter with scales 0 to 150, 0 to 300, and 0 to 600; two 5-amp. ammeters; a polyphase wattmeter, and two variable-ratio current transformers. The current transformers have three ratio taps brought out of the windings to terminals mounted on the case and are also of the hollow, or open type. The three taps brought out to terminals have 10-amp., 20-amp., and 40-amp. capacity, which are used on loads of 40 amp. or less. For loads greater than 40 amp. a different number of turns is carried through the transformers, depending on the capacity required. The largest ratio is 800 to 5, with only one wire through the transformer.

Extra-flexible cable is provided for use with the plugs connecting to the test receptacles. These plugs fit tightly into the receptacles in the line switches. In case an ammeter test is sufficient, two pieces of cables with plugs are plugged into the proper receptacles so as to short-circuit two of the three switch-blades. The current transformer is then connected around the third switch blade by other cables and plugs. With the ammeter connected to the secondary of the transformer, all that is necessary in order to take a reading is to open the knife switch. These switches, of course, are operated from a handle outside the box and all three blades break at the same time.

When a wattmeter test is required a few more connections have to be made. Two current transformers are connected one to each outside leg of the switch and the center blade is again short-circuited with a piece of cable. The potential coils of the wattmeter are wound for 600 volts; so it is unnecessary to use potential transformers when testing on a 550-volt circuit. Spring clips made from patent or spring clothes pins are used to connect the potential leads of the meter to the line. The potential leads are not placed until the line switch is open; then they are clipped onto the ends of the projecting switch blades.

The test receptacles and plugs required for testing were obtained from the Square D Co. Two sizes of flexible cable are used, No. 6 for testing motors up to 75-hp. rating and No. 2/0 for testing the larger sizes. Cables are made up in convenient lengths to suit the various installations. One man does all the testing, as no one else is allowed to take meters out of the shop.

The cost of the equipment exclusive of the meters and transformers was $500, which includes all test receptacles, plugs, cable, and installation labor. This cost has been many times returned to the company since the installation.

Recently a test disclosed the fact that a 50-hp. motor was doing about 21 hp. of actual work. At the time a 50-hp. motor was needed to drive a large pump; so the underloaded motor was used for this purpose and was replaced with one of 20-hp. capacity, saving the cost of a new 50-hp. motor. Of course, these extreme cases are rare, but it often happens that we are able to replace a 40-hp. motor with one of 30-hp. or a 25-hp. motor with one of 20-hp. rating. The tests also prove very valuable in case of a motor burning out as we are able to tell from our records what size motor will do the work. It often happens that a smaller motor is available for the job, but it rarely happens that a larger one is available. If we had no records we would not dare to install a smaller motor. In the past two years numerous tests have been made about the mill, but no accidents have occurred and no equipment has been shut down to permit testing.

Chief Electrician, LEE F. DANN.
Donnacona Paper Mills, Ltd.
Donnacona, Quebec, Can.

MECHANICAL MAINTENANCE OF Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Changing the Method of Driving Exhaust Fan Solved Motor Trouble

FREQUENTLY a baffling problem will cause the engineer of a modern industrial plant annoyance of the most exasperating nature; the more illusive the cause, the more trying it is on the nerves and patience of the engineer, as exemplified by the following experience. The Inspector for the State Department of Labor ordered that an exhaust fan be installed in the lacquer spraying room of an industrial establishment. Although the lacquering was carried on under a hood equipped with an exhaust fan, a considerable amount of fusel oil fumes escaped into the room. The Inspector held this to be detrimental to the health of the girls employed in the room, and so ordered additional ventilating facilities. Accordingly, a 36-in. exhaust fan, which was driven by a direct-connected, ¾-hp., 250-volt, series-wound, d.c. motor was installed in the upper half of one of the windows.

The installation functioned fairly satisfactorily for a while, until one day without apparent cause the armature burned out. The Inspector happened to call at the plant while the fan was inoperative and ordered that the fan be kept running all of the time, without any excuses. Consequently a spare armature was purchased and installed, but in a very short time the second armature burned out.

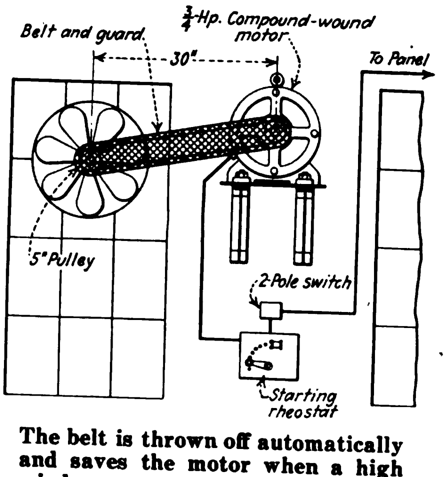
A considerable amount of new construction work was going on in the plant, and the Plant Engineer had left the maintenance entirely to the foreman of the maintenance gang with instructions to bring only matters of real importance to his personal attention. Consequently the maintenance foreman secured three spare armatures and replaced and rewound them as fast as they burned out, although he had difficulty in keeping up the pace. Finally, all four armatures were in the repair shop at one time.

The Superintendent of the Lacquering Department was annoyed because the fan was frequently inoperative, also the Inspector threatened criminal prosecution, and called the attention of the Plant Engineer to the difficulty. An immediate investigation was undertaken. Load tests, which were taken, seemed to indicate that the capacity of the motor was ample. A recording ammeter kept in the circuit for several weeks indicated that the load did not fluctuate appreciably and the difficulty appeared shrouded in mystery.

The engineer decided to watch the installation closely and visited the room several times a day for several weeks without results. At last his patience was rewarded. One day he observed the fan slowing down without any apparent reason, finally coming to a standstill, then actually reversing itself and driving the motor as a generator.

The fan was installed in a window on the sixth floor facing west and overlooking a bay. A high velocity west wind striking the fan blades would convert it into a wind turbine and drive the motor in the reverse direction as a generator across the 250-volt line, thus burning out the armature.

The installation was then modified as follows: The motor was disconnected from the fan and a 5-in. pulley installed in its place. A ¾-hp., compound-wound motor, with about 25 per cent compound field, was mounted on a wall bracket about 30 in. from the fan and belted to the fan pulley. The modification proved very satisfactory. When a strong gust of wind would strike the blades and attempt to reverse their direction of rotation the fan belt would begin to slip and in the case of a very strong wind would be thrown off. In this way the belt served as a safety link which protected the motor against the heavy overload of the sudden gust and the consequent reversal which burned out the motor. As the belt was not thrown off frequently, it was not very annoying, and the belt was replaced easily. Although individual, direct-connected motor drives have advantages in many installations, there are many cases where a safety link is necessary between the motor and its load, as in this instance.



The belt is thrown off automatically and saves the motor when a high wind reverses the direction of the fan.

Formerly a direct-connected, series-wound, d.c. motor was mounted in the window, but strong gusts of wind reversed the direction of rotation and burned out the motor. By using a compound-wound, d.c. motor mounted on the platform and connected by a belt the motor is saved because the belt serves as a safety link and is thrown off by an overload.

The installation of an exhaust blower leading to the roof and terminating in a revolving or other type of roof ventilator perhaps would have been a more satisfactory solution, but in this case it was objected to for several reasons.

Electrical Engineer, Ampere, N. J. E. OGUR.

Changing Method of Feed Solved Lubrication Problem

MANY times the modernization of the lubrication of old equipment is difficult because the construction of the bearings, unless altered in some way, does not permit using a different lubricant than the machine was originally designed to use. This is particularly true, in many instances, where it is desired to change from a grease to an oil lubricant. Often the old bearing is not tight enough to retain the oil. This is sometimes overcome by using a bottle, wick, or drop oiler which feeds a definite amount of oil to the bearing continuously. In addition, care must be exercised to see that the oil grooves are cut properly to distribute the lubricant.

An interesting problem, however, arose recently in connection with the modification of the lubrication system for a crusher which was originally built for grease lubrication. The grease, which was placed in a deep chamber reservoir, was supposed to flow down to the bearings as needed. It was found, however, that the heavy grease used, caked and failed to flow. Oil ran through too quickly, as this was a loose-fitting bearing. Also, a lighter grease ran through too rapidly.

The difficulty was overcome by installing a plug with a much smaller opening at the bottom of the grease chamber and using a grease with a light body. This small opening restricted the flow of the light grease to the amount required for the bearing. The grease was too light in consistency to cake. Plugs with openings of different diameters were tried until one was found which reduced the flow of the light grease to the proper amount required for the bearing.

Chicago, Ill. F. E. G.

Simple Methods of Quieting Noisy Gears

THERE are many reasons why gear drives are noisy. They may be made with cast teeth, they may be running at a speed too high for their particular type, they may be meshed too tightly, they may be badly worn or running on shafts that are not parallel. There is a certain amount of noise—small, to be sure—every time a tooth strikes its mate, and this, multiplied by the number of teeth and speed of revolution, builds up the roar that is so nerve racking and so unnecessary.

Recently the noise from a machine in a plant attracted notice. It was impossible for a person standing alongside the machine to be heard, except when shouting. The drive was by a 4-in. belt running at 1,800 f.p.m. from the first shaft through three pairs of gears to the fourth shaft, which turned at 3 r.p.m., a reduction of 160 to 1. Somewhere in those gear trains was the noisy member. The workmen had become used to it, looking on it as a necessary evil, and said the machine had always been noisy.

It sounded like gears too closely meshed and, from the frequency of the pulsations, it was on the first shaft. A request for a flashlight and a chance to investigate showed that the gears were bottoming in the first two trains. They were all under the machine and during the various periods of repair the bearings, which were bolted to the planed underface of the frame, had been "socked up tight" with a big wrench and there they stayed.

With such constructions, it is customary to give the bolt holes 1/16 in. of play and finally to secure the bearings by the big wrench method after a careful alignment, or else to use dowels. Undoubtedly the builder had had the shafts properly lined up, but evidently the repair crew had trusted to the bolt holes to space the shafts as they ought to be. Being under the machine where he had to lie on his back to work, the repair man had taken the quickest and easiest way, even if the machine and the employees did have to suffer.

Loosening up the first shaft's bearings and blocking it all the way back while the bolts were tightened, a start was made toward correction. Then the second shaft was loosened and moved back half the amount of the first one. The space between the gears could be seen then when the pulley was rotated back and forth. The final procedure was to cut sections of hard maple, which were wedged in between the pairs of bearings at right angles to the grain. This made it sure that they would not come together again, and if they fell out, it would show that some movement had taken place.

Any time that gears under inspection show evidence of rubbing action at the root of the teeth, noise and improper setting may be looked for. In this case it was evident at a glance. When the machine was started up again, it ran almost noiselessly.

Gear teeth are so cut that their action is rolling in mesh, not rubbing, and there is everything to lose by not maintaining the correct mesh. Teeth should never bottom. There is purposely cut at the bottom a clearance which is approximately one-tenth of the height of the tooth. When the meshing of a pair of gears maintains this clearance, almost no noise will result from running and the wear of teeth will be reduced to a minimum.

Side clearance is also provided for when the teeth are cut. This amounts to 0.002 or 0.003 in. No easier way of setting gears can be followed than to place a slip of newspaper alongside two of the teeth at the point of tangency. This clearance is readily discernible to the eye if one of the gears is moved back and forth.

One of the most frequent violations of this gear bottoming rule is found in machine shops in connection with lathe change gears. When these gears are changed, there is always a swing gear or one studded in a slot, which is set to make up for differences in diameters, or to connect up the train. Machinists are prone to push these gears up hard as they are tightened; the result is that bearings and teeth get unnecessary wear and there is a grinding noise set up that should cry aloud to supposedly trained men. Moved apart 1/32 in., the gears would run quietly and wear would be minimized.

The use of grease and oil may be commended in some cases, but when lubricant is used to cover up or relieve too tight a setting of cut gears, it is wrong practice. A film of lubricant may be needed in most cases, but that film is immediately broken down where no clearances exist.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Operating Comparison of Variable-Speed Transmission and Variable-Speed Motor

VARIABLE-SPEED drive and control for assembly conveyors and other equipment which it is desirable to operate over a range of speeds, are ordinarily obtained either by using a variable-speed transmission or a variable-speed motor. Conveyors usually travel at a very low speed and any additional high reduction between the motor and the conveyor is obtained by means of suitable gear reduction units which give a fixed reduction ratio. The experience of the Hupp Motor Car Corporation, Detroit, Mich., and the comparative cost figures should be of interest to other concerns with similar power-transmission and variable-speed problems.

This company has six style O-E Reeves variable-speed transmissions (Reeves Pulley Co., Columbus, Ind.) in operation at the present time. Assembly conveyors which are operated from the Reeves transmissions range from 200 to 300 ft. in length. The chassis-assembly conveyors, three in number, are typical of all these drives. Each is 244 ft. long and is driven at speeds of 3 to 12 f.p.m. in conveying the chassis through the various assembly operations. In the operation of these conveyor lines smooth control and increment of speed with close regulation are required over a wide range.

Power is supplied to each of the chassis-assembly conveyors from a constant-speed, 3-hp., 1,200-r.p.m. induction motor which is connected to a variable-speed transmission and a gear-reduction unit. The latter has a fixed ratio of 95:1 and the variable-speed unit gives a smooth variation in a 4:1 ratio. Conveyor chain speeds from 3 to 12 f.p.m. are readily available.

The use of a variable-speed induction motor would, in this plant, be the only practical alternative for obtaining suitable variation in conveyor speed.

Three such motors are used at the Hupmobile plant for driving three final-assembly conveyors. They have proved much less satisfactory in fineness of regulation and in dependability of operation. These motors are equipped with elaborate control equipment, but are capable of only a 2:1 speed variation which is obtained in only nine steps from the highest to the lowest. Small increments in speed are not possible.

Tabulations that have been made render it easily possible to compare the annual fixed costs for the variable-speed transmission unit with those for a variable-speed motor which, with suitable reduction gears, would give a somewhat similar result.

The use of such a variable-speed motor and gear unit would involve annual fixed charges of $71.42, considering only depreciation and average interest at 6 per cent figured over a 10-yr. period. The Reeves drive actually in use, when analyzed in the same way, shows annual fixed charges of $61.84.

The annual saving is, of course, not large but the operating advantages of the transmission unit are of additional importance. The variable-speed transmissions are, in addition, more dependable in operation and there has been no expenditure for maintenance on them in four years of use.

Furthermore, aside from its less flexible speed control characteristics the variable-speed motor must be a much larger unit than the constant-speed motor used with the variable-speed transmission. To deliver 2 hp. at half speed requires a motor capable of developing about 5 hp. at full speed. This results in much lower efficiency at all speeds and loads. At full speed and developing 3 hp. the efficiency would be 81.5 per cent and at half speed, where the load is 2 hp., the efficiency would be only 41 per cent. A 3-hp. constant speed motor would have an efficiency of about 85 per cent, varying little with the variation of load between 66 and 100 per cent of motor capacity. The use of the constant-speed motor results in a saving of 1.87 kw. at low speed.

On the other hand, the variable-speed drives can be locked at any speed, thus assuring a set production rate. This is invaluable in maintaining a predetermined production schedule. Close maintenance of a fixed speed has not been possible with the variable-speed motors, as now installed, and their control over conveyor movement has, on the whole, been far less satisfactory than that obtained with the use of the variable-speed transmissions.

PAUL J. ZIEGELBAUR.
Assistant Superintendent of Maintenance,
Hupp Motor Car Corp.,
Detroit, Mich.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Simple and Inexpensive Type of Cross-Over Connector

IT SEEMS rather surprising that among the numerous patented wire connectors, there are none that are designed for use on cross-over connections. In my own work I have discovered the need of a cross-over connection from time to time and, disliking to make a basket splice which at the best would be bulky and unsightly, I found that two types of connectors could be made quite easily in the shop.

For small wires, the connectors may be made from heavy sheet copper of a gage to correspond to the required carrying capacity of the joint. In making the connector a flat sheet should first be cut out, as shown at *A* in the accompanying illustration, and then bent into form, as shown at *B*. The connector is now ready to be pinched onto the wires and soldered into place. Even when taped, these connectors make only a small bulge on the wires.

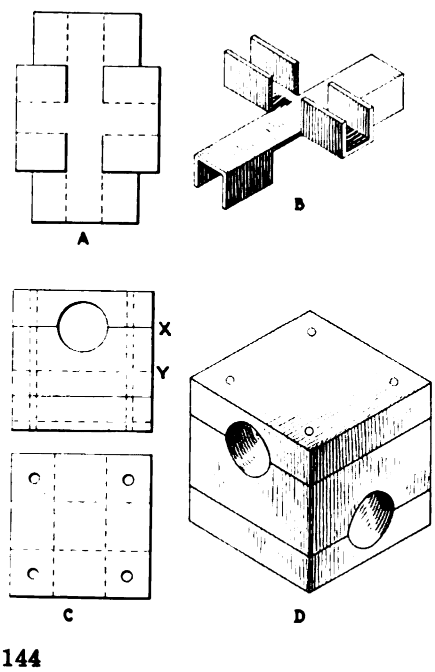
For large wires, a stronger type of connector is needed. A piece of brass of cubical shape should be used for these. Through the cube drill two holes exactly the size of the wires to be connected, the relative positions of these holes being shown at *C* in the illustration. Next drill four small holes down through the corners of the cube, and with a hacksaw cut through on the lines marked *X* and *Y*. The finished connector is shown at *D* in the illustration.

To assemble, place the three pieces in position on the wires, insert four through bolts in the small holes, and take up on the nuts until the cut faces pull together. The hacksaw in cutting removes enough stock so that the parts of the connector clamp down firmly on the conductors.

JAMES P. MARSHALL.
Providence, R. I.

These handy cross-over connectors make only a small bulge on the wire, even when taped.

The type of connector shown at *A* and *B* is used on small wires, while the one shown at *C* and *D* is suitable for large wires.



Quick Method of Replacing Worn Collector Rings

A FEW years ago I took charge of a plant containing several rotary converters which were originally designed for operation at 25 cycles, but had later been rebuilt for 60-cycle operation.

The original a.c. brushes and slip rings were still in use, but the new rotor speed of 1,200 r.p.m. as compared with the original speed of 500 r.p.m. had proved destructive to the copper leaf brushes and the slip rings.

After some experimenting, a carbon type brush was found that would operate satisfactorily under the exacting conditions of high speed and heavy current, but by the time we had found a satisfactory carbon brush the collector rings were so worn and pitted that it was decided to replace them. As they were found to be forced or shrunk on a heavy iron spider which was heavily insulated with mica, it was decided to do as much of the repair work as possible directly on the job in order to avoid delay in the repairing of the rings. The following method was employed:

A portable commutator turning tool was mounted on the bearing cap at the a.c. end of the machine, and as the frame of the rotary was insulated from the ground, we could clamp the cutting tool directly on the bearing cap with no fear of burning the cutting point. To obtain the desired low speed for the rotary converter, a water barrel resistance was cut in the positive armature lead circuit, so that full voltage, 650 volts, could be applied to the field from the station bus. This arrangement gave ample power at any desired low speed.

While the rotor was running at reduced speed, the old rings were all trued up to the same diameter. New rings, cast from a special alloy, were then ordered from a local foundry and machine shop. These rings were bored so that their inside diameter was $\frac{1}{32}$ in. less than the outside diameter of the old rings, as the new rings were to be shrunk in place.

These new rings, which measured about 13½ in. outside diameter, 11 in. inside diameter, and 1½ in. wide, were expanded about ⅛ in. by the heat of six gasoline torches. After the new rings had cooled and shrunk into place, the cutting tool was again used to true them up. The job was completed in about 12 hr.

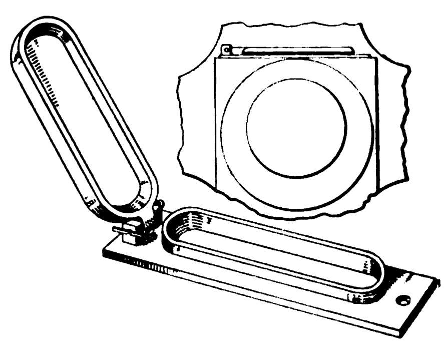
PHILIP N. EMIGH.
Chief Engineer,
The Mountain Water Supply Co.,
Indian Creek, Pa.

Handy Oil Well Cover Permits Easy Access to Bearing

IN THE plant where the writer formerly had a large number of motors in his care, it was necessary to have ready access to the oil rings when the motors were started up after a regular 24-hr. shutdown during cold weather, for the oil at such times generally congealed to the consistency of vaseline. Under these conditions, the oil rings will not turn when the motors are started, and the bearings will often heat up locally before the oil is thin enough to allow the rings to revolve.

Most motor manufacturers equip their motors with stamped steel covers, which are fastened with screws over the top of the oil well. On the other hand, most of the men who started the motors in our plant were rated only a little higher in rank than common laborers; so the oil rings used to be neglected, for these men seldom had a screwdriver to remove the oil well cover so that they could start the oil rings turning. We decided to devise an oil well cover that would keep the dust out of the bearing and yet allow ready access to the bearing, for inspection purposes. The result of our efforts to devise a cover is shown in the accompanying illustration. We had no facilities for making these covers of cast iron, but there were a number of large, junked motor bearings on hand, so we

This oil well cover enables the operator to gain quick access to the oil ring of a motor bearing.



made the covers of white metal. These bearings were melted in an ordinary stove and cast in sand molds at the electrical shop.

A number of our Crocker Wheeler motors had broken oil well covers; so we used these as patterns. None of our electricians was experienced in foundry work, but as they had a general idea of how castings are made, they soon turned out beautiful castings that required very little finishing. The white metal proved to be nearly as hard as cast iron and, after the covers were installed, no bearing troubles were experienced on the motors so equipped.

Possibly some of the readers of INDUSTRIAL ENGINEER may believe that it is cheaper and more satisfactory to purchase oil well covers from the manufacturer, but the writer is of the opinion that it would be rather difficult to secure covers of this kind for all types of motors. This is especially true if one has some 30 or 40 different sizes of motors produced by a dozen different companies. I have recently been informed that one of the motor manufacturers is now equipping his motors with a cover very similar to the one just described, with the exception that the covers are made of stamped steel and a spring is used to keep the covers closed when the bearing is not being inspected.

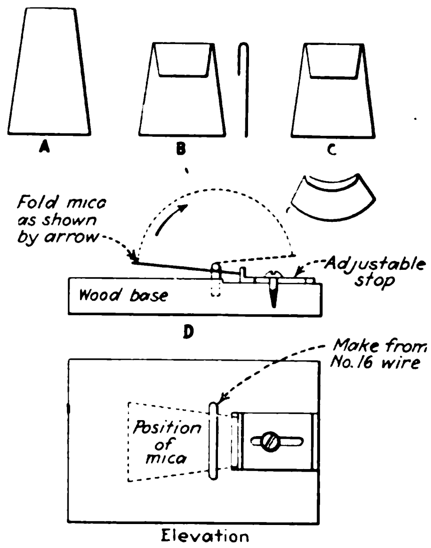
CHAS. A. PETERSON.
Fairbanks, Alaska.

Simple Method of Reinforcing Mica V-Ring

MANY times it is desirable to reinforce a mica V-ring in a commutator, either on account of its having been patched or when using home-made rings. Nearly all factory V-rings are made in one piece, whereas home-made rings are made in two pieces, which leaves a crack or opening at the point of the V. This is an undesirable condition, as current may leak through this opening and cause the commutator to fail in service.

An easy and practical method of reinforcing mica V-rings, which will be described later, has been used successfully for many years. All of the material needed for one V-ring is a few ounces of No. 4 grade white India mica. This is a standard grading and can be obtained from your regular source of supply of insulation, No. 4 grade white India mica being about the right size for most jobs. India mica is recommended because it splits easier and more evenly into thin sheets than do the various American grades of mica.

The mica is first cut into wedge-shaped pieces as shown in the accompanying illustration at *A*, the point of the wedge being left blunt. The exact size of the mica should be determined from the mica V-ring. The wedge-shaped pieces are then split into thin sheets 0.002 in. to 0.003 in. thick. After splitting, the thin sheets are folded, as in *B*, by means of the adjustable device shown at *D*. Several thin sheets may be folded at a time, taking care to make the legs of the V the same length as the height of the mica V-ring and the width of the bevel part of the



Form for folding mica to shape shown at B

This shows how the reinforcing pieces of mica are cut and formed.

ring. The legs will be of unequal length in most cases. While folded, the sheets are rolled or bent in a direction at right angles to the first fold. This rolling gives each sheet a circular shape to fit the inside of the V-groove in the commutator. The rolling is done with the thumb and forefinger of each hand, the work being done on a hard surface.

These pieces of mica are used to line the commutator V in such a way that each piece will overlap the one previously put into place in the same way that shingles are laid. Two layers of mica should be put in the commutator and then the mica V-ring is put into place inside of the two layers of mica, after which the commutator is tightened in the usual way.

If after thoroughly cleaning out the commutator V, the surfaces are coated with shellac and the mica is put in place while the shellac is wet, the mica insulation will then be held more securely. The old mica V-ring should be cleaned of all dust and dirt and given a coat of shellac before using, which should be allowed to dry before the V-ring is put in place. C. B. KECK.
Cleveland Heights, Ohio.

How to Make Rheostat for Testing Fields of D.C. Motors and Generators

TESTING the fields of direct-current motors and generators frequently requires a rheostat of such capacity in the first few steps that only a comparatively expensive commercial rheostat will suffice. To meet this need for a suitable and inexpensive rheostat in an Eastern manufacturing plant, one was built, mostly with material on hand, as described below.

The 230-volt motor for which this rheostat was first designed has a shunt resistance equal to 36 ohms, and is of the adjustable-speed type, 300 to 900 r.p.m., rated at 48 hp. for 1 hr. with a rise of 50 deg.

The rheostat has a range from 0 to 100 ohms and from 100 to 200 ohms, adjustable in 10-ohm steps, with a current capacity of 5 amp. on the first step and 1.69 amp. on the last step. The resistance consists of ten 10-ohm wire resistance units and one 100-ohm unit, which is cut in or out by a single-pole, single-throw switch. Single-pole switches are used to cut the rheostat out of the motor field circuit. In order to obtain the required capacity in the various steps at the least cost, the resistance units were purchased in the sizes shown in the accompanying table. It will be noted that the load on each unit is always considerably within its rated capacity.

The resistance units were mounted on an asbestos wood block, $\frac{3}{8}$ in. thick, which is secured to the back of a maple panel. The arm and contact points were taken from an old, discarded rheostat.

The maximum normal shunt field current within the capacity of the rheostat is 9.75 amp. for a 115-volt motor, 6.75 amp. for a 230-volt motor, and 5.75 amp. for a 550-volt motor. Any shunt or compound wound motor having a normal field current not exceeding the values given can be safely handled, even on the first step of 10 ohms.

The cost of the material used was $16.40, and the cost of labor for assembling was $7.50.

J. M. WALSH.
Asst. Chief Engineer,
Gurney Elevator Co.,
New York, N. Y.

Resistance and Load Data of Rheostat Used for Testing D. C. Motor and Generator Fields

Step No.	Resistance Ohms	Rating Watts	Load Amp.	Load Watts
1	10	270	5.00	250
2	10	189	4.10	168
3	10	144	3.50	122
4	10	108	3.03	92
5	10	90	2.68	72
6	10	75	2.40	58
7	10	60	2.17	47
8	10	45	1.98	40
9	10	45	1.83	34
10	10	45	1.69	29
Extra	100	361	1.69	290

New Equipment

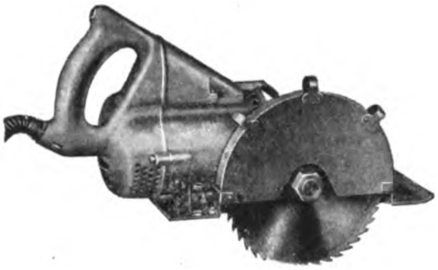
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Portable Electric Saw

THE Speedway portable electric saws, recently developed by the Electro-Magnetic Tool Co., 19th & 52nd Ave., Cicero, Ill., are made in two sizes; the Type 177 saw and the Type 178 saw.

The Type 177 saw is a 15-lb. tool which operates either a 6-in. or 7-in. blade that can be removed without the use of any tools by simply removing a nut. The 6-in. saw blade gives a maximum cut of 1⅝ in. The 8-ft. extra tough rubber lead cord is furnished with a patented split plug. The no-load motor speed is 3,600 r.p.m. and this saw may be operated from any lighting



Speedway portable electric hand saw.

socket, the motors being furnished for either 220, 110, or 32 volts.

The Type 178 saw is sturdier and heavier, weighing 22 lb. It is equipped with a ⅛-hp. universal motor, chrome nickel steel, heat-treated gears and ball bearings throughout. The 8-in. saw blade takes a 2⅝-in. cut. The no-load speed is 1,500 r.p.m.

High Interior Reflector

THE new Pittsburgh reflector No. I-1000, manufactured by the Pittsburgh Reflector Co., 304 Ross St., Pittsburgh, Pa., is designed particularly to meet the conditions existing in high industrial interiors where the lighting unit must be from 25 to 50 ft. or more above the floor, and for lighting through skylights. This reflector, which is of glass, silver plated, is said to be very concentrating, the bulk of the reflected light being confined within the 0-40-deg. zone, with a cut-off at approximately 60 degrees above the nadir. The maximum percentage of the reflected light flux reaches the work plane without striking the walls. These reflectors should not be installed at elevations less than 25 ft. for the 1,000-watt lamp and 20 ft. for the 750-watt lamp.

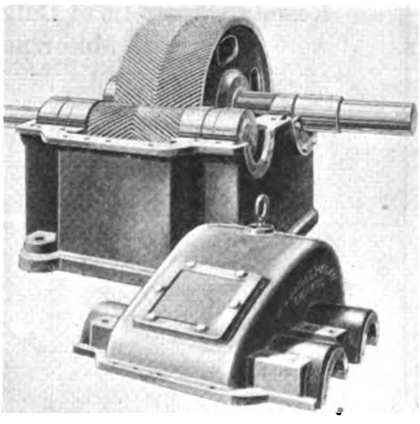
There is furnished with the reflector a porcelain mogul socket equipped with

New Pittsburgh No. I-1000 reflector

special casting at top, tapped for ¾-in. conduit hanger and equipped with a special safety holder. The socket and holder are both supported from the casting, thus relieving the socket and electrical connections from any strain whatsoever. Provision is also made for using 300- and 500-watt lamps in this reflector when necessary.

Continuous-Tooth Herringbone Speed Reducers

DEVELOPMENT of continuous-tooth herringbone gears for use in speed-reducing units has been announced by D. O. James Manufacturing Co., 1120 W. Monroe St., Chicago, Ill. A unit with the cover removed is shown in an accompanying illustration. Each individual tooth is brought to an apex and has the shape of a completed V. The tooth is not broken and the apex is not rounded to provide for tool clearance.



James continuous-tooth herring-bone gear speed reducer.

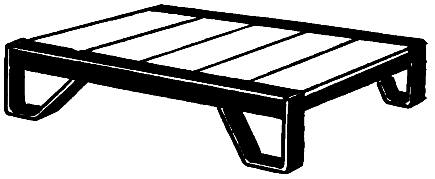
The teeth are of involute form and are cut with a 20-deg. pressure angle and a 30-deg. helix angle. Due to the continuous form, end thrust is neutralized. An overlap of approximately 50 per cent is obtained, so that the tooth action is smooth, continuous and noiseless, and no shock is produced when the load passes from one tooth to another, according to the manufacturer; two teeth are always in mesh in the plane of the axis.

It is said that the load is distributed over the full width of the teeth, and consequently large loads can be carried by small gears with high efficiency. For the same reason, greater reduction ratios can be obtained, together with higher rim speeds, longer life, and less power consumption; also less space is required because fewer reductions are necessary.

These continuous-tooth, herringbone gears are being built in reduction ratios ranging from 2:1 to 150:1, and for carrying loads from 2 to 200 hp.

Steel-Frame, Lift-Truck Platform

CONSTRUCTION and operating advantages of the new steel-frame, lift-truck platform or skid, shown in the accompanying illustration, are described by the manufacturer, Lewis-Shepard Co., Watertown Station, Boston, Mass., as follows:

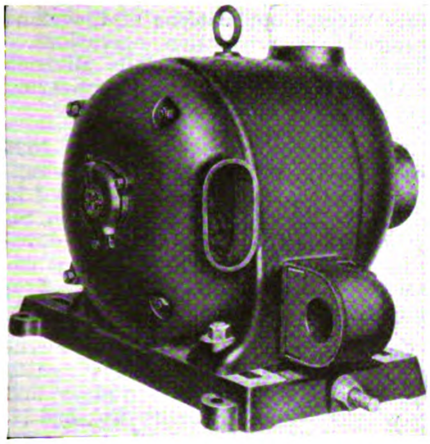


Arc-welded, steel frame on Lewis-Shepard lift-truck platform.

The clearance from the underside of the platform to the floor is the same on both sides and both ends, which permits a lift truck to be backed in under either side or either end. This new platform is steel bound all around; that is, all boards, in particular those at the ends, are protected by a steel binding. This extra armoring protects the end boards which must stand the bump of the lift truck when it is backed in under either end. The entire metal structure is arc-welded into the equivalent of one solid piece. It is stated that not a single hole is bored, and not a bolt or rivet is used in the entire platform. The top of the platform is flat. The steel does not extend above the boards nor the boards above the steel, which gives a flush top.

Inclosed Ventilated Motor

THE new Type EHJ motor has been especially designed by Fairbanks, Morse & Co., 900 South Wabash Ave., Chicago, Ill., for installation where fire prevention associations and insurance companies recommend the application of an inclosed motor on account of fire hazards from inflammable dust or explosive vapors. They are also intended to be used where the conditions of service are unusually severe, due to exces-



Fairbanks-Morse Type EHJ inclosed, self-ventilated motor

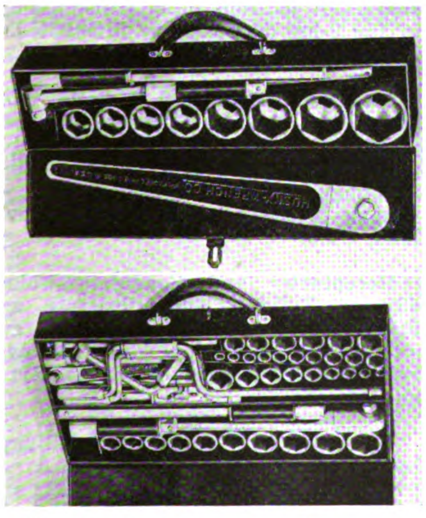
sive humidity and temperature, heavy dust, abrasive particles, and so on.

These machines, which are of the double-squirrel-cage type, are completely inclosed by rigid cast-iron frames without the use of any sheet metal covering. Flanged inlet and outlet openings are provided for the attachment of ventilating ducts. It is claimed that these machines have a starting torque of 200 to 250 per cent of that developed at rated load, with a starting current less than 450 per cent of full-load current. No centrifugal switches, variable resistances, or slip rings are required on these motors. The only external control equipment required is a properly fused, double-throw line switch.

Industrial Socket Wrench Sets

ANNOUNCEMENT is made by the manufacturer, The Husky Wrench Co., Twenty-seventh and Florence Sts., Milwaukee, Wis., of the marketing of new socket wrench sets especially selected for industrial use. Of these the Giant set is the most powerful set and is designed for heavy work around machinery and power plants. This is known as Set No. 512, and is shown in the lower of the accompanying illustrations. This set contains a 20-in. ratchet with heavy-duty No. 8 hex-plug; combination tee 12 in. long; handy grip, 7 in. long; swivel extension, 17 in. long; and eight hexagon sockets for $1\frac{3}{8}$- to $2\frac{3}{8}$-in. nuts in the more commonly used sizes. This is packed in a steel carrying case and weighs 35 lb.

The No. 494 Dual set combines both Husky standard and heavy-duty sets conveniently arranged in a compact steel carrying case. A wide range of sockets and handles is included in this unit. The standard set contains, in addition to the various handles and extensions, 16 hexagon sockets from $\frac{7}{16}$ to $1\frac{1}{4}$ in. and nine square sockets from $\frac{3}{8}$ to 1 in. Ten hexagon sockets from $\frac{15}{16}$ to $1\frac{5}{8}$ in. are included with the heavy-duty equipment in this box. This set is illustrated in the upper of the accompanying illustrations.



The Dual Husky socket wrench set (above) is a combination of a standard and heavy-duty set. The Giant set (below) is for very heavy work.

Fifth-Wheel Trailer

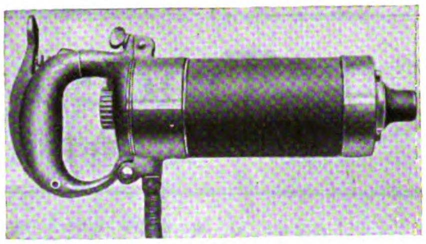
TRAILERS of the rubber-tired, fifth-wheel type have been developed by the Clark Tructractor Co., Buchanan, Mich. The tongue is used both for steering and for coupling one to the other, or directly to the tractor. The trailer is rated 3 tons capacity and is designed for handling bulky loads, it is said.

The platform is built of hardwood $1\frac{1}{4}$ in. thick, set flush with the frame. The corners are rounded and the ends are bound with 4-in. steel bands. Dimensions of the platform are 6 ft. 3 in. in length by 3 ft. in width. The platform is 20 in. high.

Full Hyatt bearing equipment is used on all wheels. The front wheels are 15 in. in diameter with $3\frac{1}{2}$-in. face. The rear wheels are 18 in. in diameter with 3-in. face. Hard rubber truck tires are pressed on all wheels, but steel wheels can be furnished if desired. The axles are $1\frac{1}{2}$ in. square, turned to $1\frac{7}{16}$ in. for the wheel spindles.

Electro-Magnetic Hammer

IMPROVEMENTS in the electro-magnetic Simbi model 26 hammer, shown in the accompanying illustration, are announced by The Fermot Co., 200 Broadway, New York, N. Y. This hammer is operated by hand and resembles a pneumatic hammer somewhat in size and shape. In operation an alternating-current solenoid actuates a movable plunger the recoil of which is governed by means of an adjustable helical spring. With 60-cycle current, the frequency of percussion is 7,200 strokes per minute. This hammer is used for drilling holes in concrete or stone, for chipping, beading, or calking. The new model hammer has the feed cable attached to the body of the hammer instead of to the handle, which, it is said, gives the operator more freedom of movement. Also, the aluminum housing that covered the body of the hammer in the old model has been eliminated to facilitate quicker cooling of the coil and incidentally has reduced the resounding humming which is caused by the high frequency of the vibration. It is stated that an in-



Improved Simbi model 26 electric hammer

creased efficiency of 30 per cent has been obtained in this new model. This hammer is distributed in the United States by the Rawlplug Co., Inc., 66 W. Broadway, New York, N. Y.

Red Line Positive Printing Paper

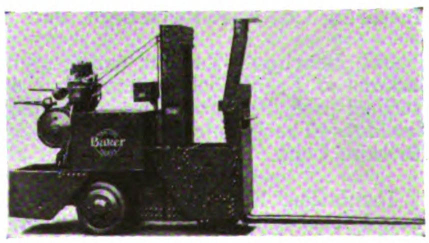
DEVELOPMENT and marketing of a positive-print paper with a dark-red or maroon line on a light-cream background, which is produced from the original tracing without the use of a negative, is announced by Eugene Dietzgen Co., 954 Fullerton Ave., Chicago, Ill. This carries the trade name of Ozalid printing paper.

Ozalid is printed in the same manner as are blueprints, but is developed dry by brief exposure to ammonia-water vapor. Because of this method of development it is said that the paper does not shrink or wrinkle and is true to scale, besides retaining its original strength. It is stated that the print produced is non-fading and can be shaded and colored, or written upon with pencil or ink. If prints are made on thin Ozalid paper they can be used for reproduction, it is said.

Hy-Lift Truck for Carrying Crates

RECENT adaptation of the Baker Hy-Lift truck for carrying large crates or similar packages has been announced by the manufacturer, The Baker-Raulang Co., Cleveland, Ohio. As the accompanying illustration shows, the carriage is fitted with two long forks in place of the usual platform and two clamps are provided in the upright section for securely holding either one or two packages by clamping at the top.

The clamping action is entirely automatic and takes place as soon as the truck commences to lift. One crate may be picked up and placed on top of another and then both of them carried on one load. In this case, and on high crates, the lower clamp drops back out of the way and the upper clamp comes into operation.



Adaptation of the Baker Hy-Lift truck for lifting and carrying crated goods.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Switches—Various types of Hubbell switches used for interior wiring are described and illustrated in Circular No. 277.—Harvey Hubbell, Inc., Bridgeport, Conn.

Tapered-Roller Bearings—An illustrated booklet describes the results of recent developments in the use of tapered-roller bearings as applied to machine tool equipment.—The Timken Roller Bearing Co., Canton, Ohio.

Warning Lights — New models of lanterns, illuminated sign and signal lights are illustrated in color in a 24-page booklet. — The Nichols-Lintern Co., 7960 Lorain Ave., Cleveland, Ohio.

Material Handling Equipment—Various applications of Cleveland tramrail systems in a foundry are illustrated in a leaflet.—The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Carbon Brushes—A 12-page catalog describes and illustrates various grades of Carenco brushes, besides listing other carbon products, giving instructions for ordering and price information.—Carbon Engineering Co., Milwaukee, Wis.

Graphic Meters—A heavy-duty meter element for use in d.c. meters and a quick-trip graphic instrument driven by a spring motor are described and illustrated in Bulletin 1126.—The Esterline-Angus Co., Indianapolis, Ind.

Motor Repair Equipment — Fiber fuse pullers, coil and wire tamping tools, feeler gages, wire insulation scrapers, and other maintenance and repair equipment are described and illustrated in a recent folder.—Grinder Sales Co., 526 West Fort St., Detroit, Mich.

Insulating Oil—A general discussion of the properties, with particular reference to dielectric strength, flash and fire points, of Universal Wemco C insulating oil is contained in leaflet 20,-291.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Ball Bearings—Various motor applications of Fafnir ball bearings are described and illustrated in a 30-page booklet.—The Fafnir Bearing Co., New Britain, Conn.

Insulation Resistance Testing—The new Pocket Manual of Megger Practice contains much information that should be helpful to users of Megger instruments and to others who are interested in the systematic testing of the insulation resistance of equipment. The contents of this manual includes insulation and measurement of its resistance, directions for various insulation tests, special directions for Megger testing, principle of operation and general instructions for using Megger instruments.—James G. Biddle, 1211 Arch St., Philadelphia, Pa.

Arc Welding — A 31-page booklet, S.P. 1767, deals with the arc welding of structural steel and gives a detailed description of the results of the tests conducted on welded joints at the Carnegie Institute of Technology.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Grounding Devices — Loose-leaf sheets give the standard grounding rules and regulations adopted by the State of New Jersey and show by sketches the approved methods of using Groundulets for this purpose.—Groundulet Co., 480 Broad St., Newark, N. J.

Industrial Thermometers — The revised edition of catalog 625A devotes 48 pages to a description and discussion of the various industrial thermometers manufactured by this company. In this catalog particular care has been taken to show the various types, shapes and forms of these thermometers to facilitate ease and accuracy in ordering this equipment.—C. J. Tagliabue Mfg. Co., 18-88 Thirty-Third St., Brooklyn, N. Y.

Portable Elevators — Bulletin 90-D describes the Revolvator electric portable elevator with worm-gear drive and illustrates its special features.—Revolvator Co., 336-352 Garfield Ave., Jersey City, N. J.

Corduroy Cranes—Bulletin 42X gives numerous illustrations of the work performed in industrial plants by P & H corduroy cranes, and also shows their construction. — Harnischfeger Corp., Milwaukee, Wis.

Air-Cooled Transformers — Bulletin 1026 describes and gives prices on the line of Sorgel air-cooled, dry-type transformers. This line consists of single-phase, 110/220-volt transformers up to 30 kva., three-phase transformers to 50 kva., balance coils, new code lighting transformers, insulating transformers, auto-transformers, welding transformers, and transformers for special applications. It is stated that this equipment has been especially designed for high efficiency and maximum ease of installation.—Sorgel Electric Co., 91 W. Water St., Milwaukee, Wis.

Tramrails—A series of folders illustrate various applications of Cleveland tramrails in production operations.—Cleveland Electric Tramrails Division of the Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Flexible Couplings — Bulletin 1026 describes the Nicholson flexible coupling, which is an all-metal coupling in which the two flanges are coupled together by floating steel keys in dovetailed slots. The entire coupling is encased.—W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa.

Cast-Iron Pulleys—A series of circulars discuss the quality of castings in Pyott Red-Face cast-iron pulleys and fly wheels.—Pyott Foundry Co., 328 N. Sangamon St., Chicago, Ill.

Chain Block — A circular describes the new Morris Gravity-Lowering chain block which is made in various capacities from ½ to 5 tons and, it is stated, saves 90 per cent of the time spent in lowering loads.—Herbert Morris, Inc., Buffalo, N. Y.

Monorail Equipment — A folder describes the American monorail equipment, which includes a special rail mounting and support, trolleys for special purposes, switches, and ball-bearing trolley wheels for replacement on other systems. — The American MonoRail Co., W. Sixty-Seventh Street and Pear Ave., Cleveland, Ohio.

Electric Hammer—A folder describes some of the many uses of the Ajax electric hammer, which weighs 10 lb. and is said to deliver 2,400 blows per minute. This may be used for cutting concrete, stones, trimming castings, or other work.—Ajax Electric Hammer Corp., 117 W. Sixty-Third St., New York, N. Y.

Speed Reducer—A circular describes the Morrison speed-reducing transmission which is of the spur-gear reduction type in which the driven spindle may be adapted to a desired height by loosening a clamp screw and moving the spindle in a complete circle so that it will line up directly with the driving shaft. In addition, other transmissions of the 2-hp. capacity are illustrated.—Morrison Machine Co., Paterson, N. J.

Flexible Coupling—A bulletin illustrates the various Climax universal joints for propeller shaft assembly and power transmission, and flexible couplings of the cord-disk type. — Climax Motor Appliances, Inc., Cleveland, Ohio.

Receptacles and Condulets—Folder 43 and Bulletin 2093 illustrate and describe a line of plug receptacles and safety switch condulets for light power requirements.—Crouse-Hinds Co., Syracuse, N. Y.

Handbook on Gearing — A 78-page book entitled "Blue Book on Gearing" gives considerable engineering data and other information on rawhide, cut metal, planed bevel, herringbone, spiral and worm gears and racks.—The Horsburgh & Scott Co., 5110 Hamilton Ave., Cleveland, Ohio.

Volume 85 New York, April, 1927 Number 4

G. A. VAN BRUNT
Editor
D. H. BRAYMER
Consulting Editor

INDUSTRIAL ENGINEER

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

A. J. WHITCOMB
Contributing Editor
F. E. GOODING
G. H. FAIRBANKS
Associate Editors

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Contents

Departments

Who Reads Your Copy of Industrial Engineer?

WHILE visiting a large factory recently, one of the editors saw on the desk of the plant engineer a torn and dirty copy of INDUSTRIAL ENGINEER. The cover was missing, some of the pages were torn out and that copy had evidently been handled a good deal. In response to an inquiry, the plant engineer said:

"I pass my copy around among my foremen and call the attention of each one to the articles that should be of particular interest to him. The men are not supposed to tear out any pages, but they do, and I cannot blame them, because they find so many ideas that they can use to advantage. It's hard on my copy, but I am willing to sacrifice that much for the increased efficiency with which my men handle their jobs. INDUSTRIAL ENGINEER has shown us the solution of many difficult problems."

That soiled and battered copy was an eloquent testimonial to the fact that the best possible use is being made of the wealth of practical operating information which every issue contains. In that plant INDUSTRIAL ENGINEER is permitted to serve its intended purpose.

The editors will be glad to know the steps that other operating executives are taking to make this publication serve them most effectively.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

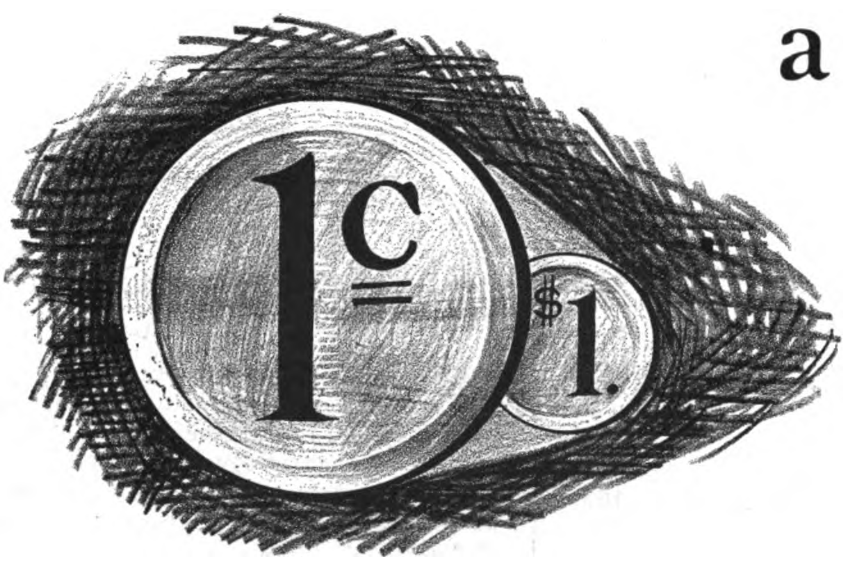
JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

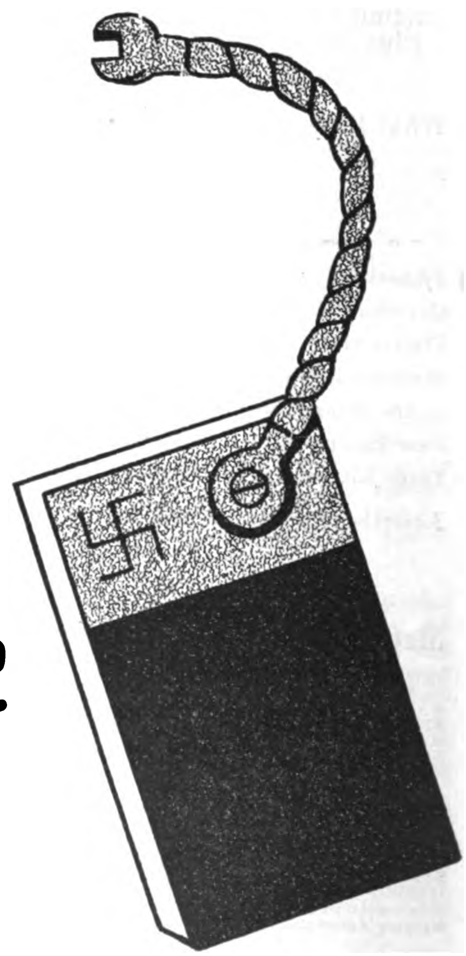
WASHINGTON, Colorado Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4
Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record — American Machinist
Power — Chemical and Metallurgical Engineering
Coal Age — Engineering and Mining Journal
Ingeniería Internacional — Electrical Merchandising
Bus Transportation — Electric Railway Journal
Electrical World — Successful Construction Methods
Industrial Engineer — Radio Retailing
Electrical West
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.

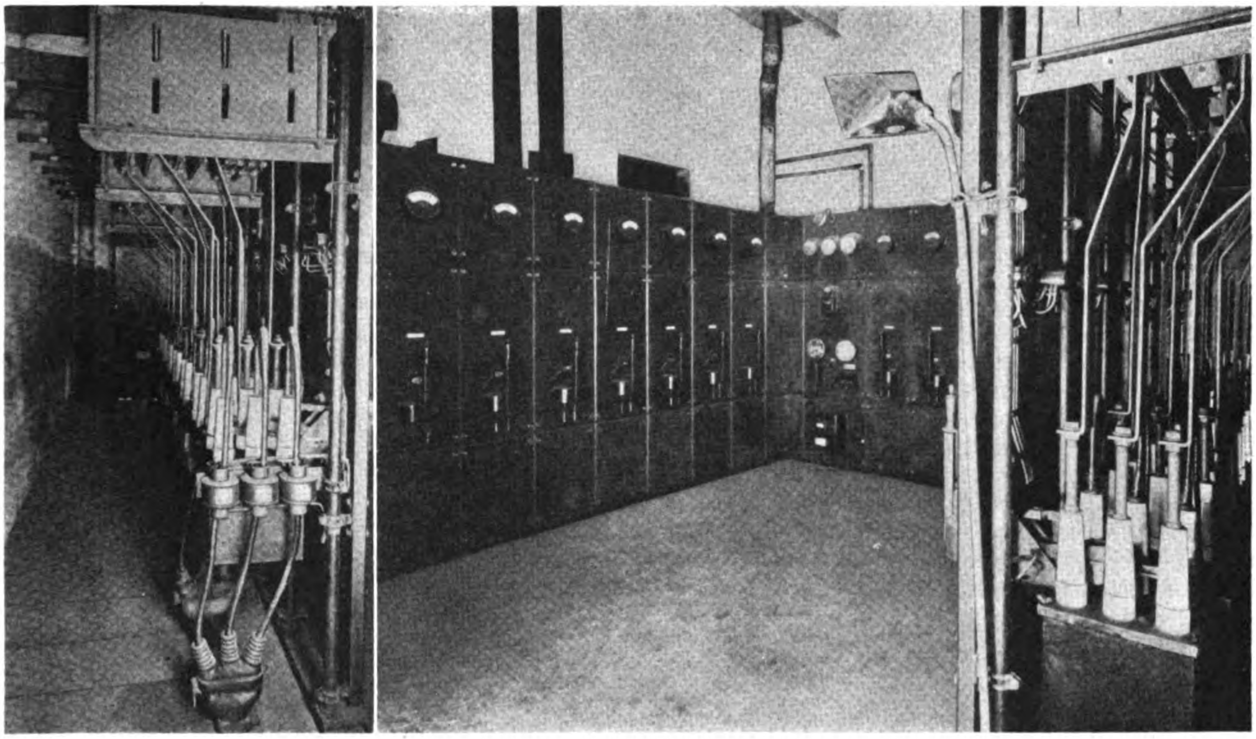

1¢
$1.



INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of
Electrical and Associated Mechanical Systems in Mills and Factories

Volume 85 New York, April, 1927 *Number 4*



Two views showing front and back of the switchboard.
The switchboard contains one instrument panel, and nineteen three-section distribution panels, each controlling a building or group of buildings, and is built on three sides of a square. The transformer room is on the opposite side of the wall to the left.

Changing a Distribution System From D. C. to A. C. Service

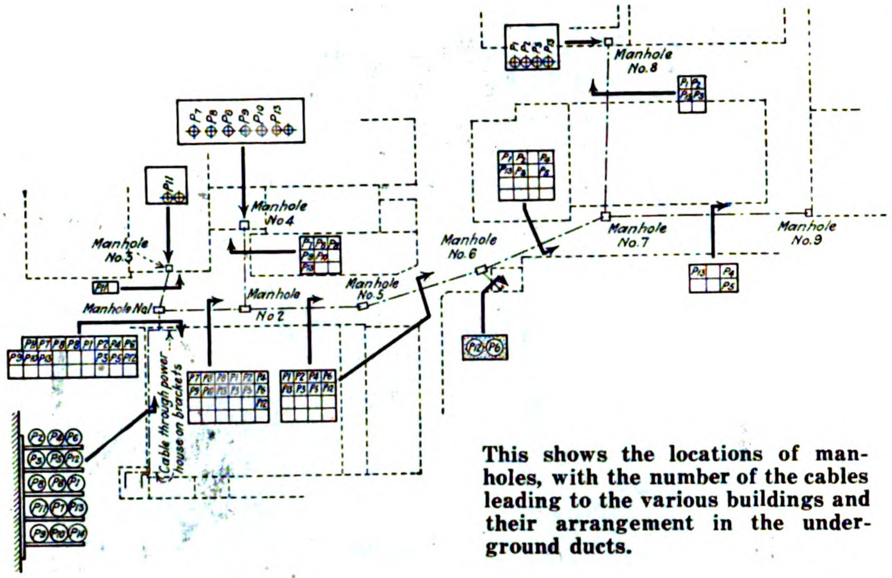
By THOMAS C. HAYES
Chief Electrician,
Wilson & Co., Union Stock Yards,
Chicago, Ill.

OPERATING conditions in a meat-packing plant, due to the steam, condensate, water, ammonia, brine, and animal acid fumes to which the electrical equipment is exposed, are especially severe, particularly on direct-current motors. The plant of Wilson & Co., one of the packing houses grouped around the Union Stock Yards in Chicago, operated until about 3 years ago on 230-volt direct current, generated in our own power house and distributed over a two-wire system.

When I became connected with the Electrical Department in Chicago about 6 years ago, the cost of maintenance was very high due to the many burnouts and other interruptions to service resulting largely from the effect of moisture and the particular operating conditions. Interference with operation is a very serious problem in connection with the meat-packing industry.

Careful and thorough inspection of the motors, with particular attention where possible to wiping and cleaning armatures and providing protection against dripping moisture, reduced the motor failures to about three a month. However, the electrical equipment was old and was reaching the point where we would soon have to consider renewing a large part of it.

The advantages of alternating-current equipment with its lower cost of maintenance were investigated, together with the question of whether to buy or continue to generate our power. One of the factors considered when making the decision was that if we were to continue making our own power we would have to install practically an entirely new power plant, including boilers,



This shows the locations of manholes, with the number of the cables leading to the various buildings and their arrangement in the underground ducts.

stack and generating equipment. It was eventually decided to purchase power from the Commonwealth Edison Co. at 12,000 volts, 60 cycles, three phase, instead of putting in a new generating plant, and change all drives to 440-volt, alternating-current motors, with 110-volt, single-phase lighting circuits.

This, of course, required an entirely new distribution system. None of the old distribution systems, except an overhead transmission line, as will be mentioned later, could be used, because individual circuits had been added as necessary when additional equipment was installed—a common condition in many old plants.

The Wilson plant consists of 97 buildings covering 38 acres. Some of the buildings are ten stories high and contain the wide variety of lines of work in connection with a packing house.

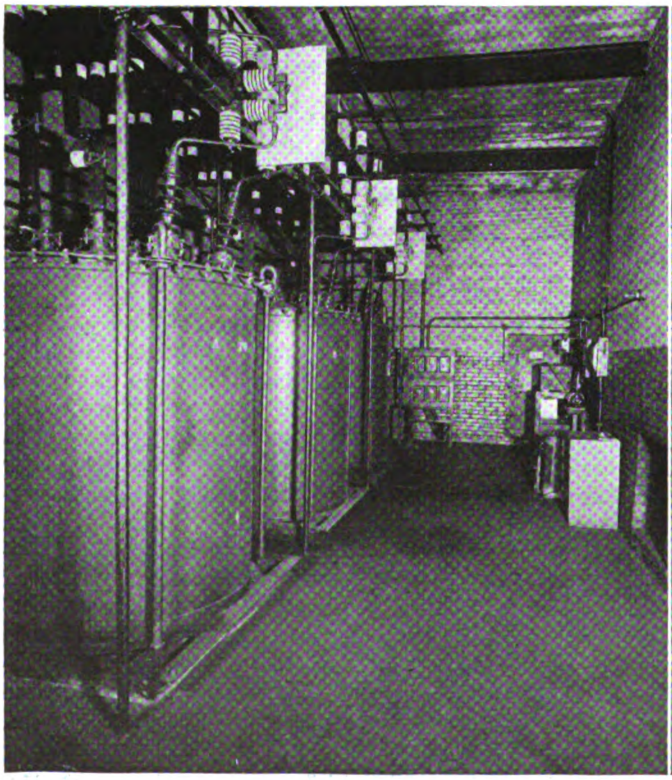
Continuous operation of the plant is so vital that it was decided to have two sets of 12,000-volt feeders run into the plant. One of these connects directly with the Crawford Avenue generating station of the Commonwealth Edison Co., and the other with the Commonwealth Edison substation, located in the yards a few blocks away. This substation is connected with two of the other Commonwealth Edison generating stations through several direct lines.

If the lines from Crawford Avenue should fail for any reason, we still receive power through the substation, as this feeder is always in service. As with all Commonwealth Edison installations of this kind, we receive power on what is known as a loop system. Both sets of high-tension lines come into the plant underground and are brought up to the transformer switchroom, which is on the second floor in a room adjoining the old power house. The concrete barriers and compartments for the equipment in the switching room were laid out and poured in a single slab with all openings cored out. It was not necessary to ream out a single hole, which makes us quite proud of the job. The open sides of the concrete switching compartments are closed with Transite asbestos board (Johns-Manville, Inc.) doors.

Each compartment is carefully marked by stenciling on the Transite front, as shown in an accompanying illustration.

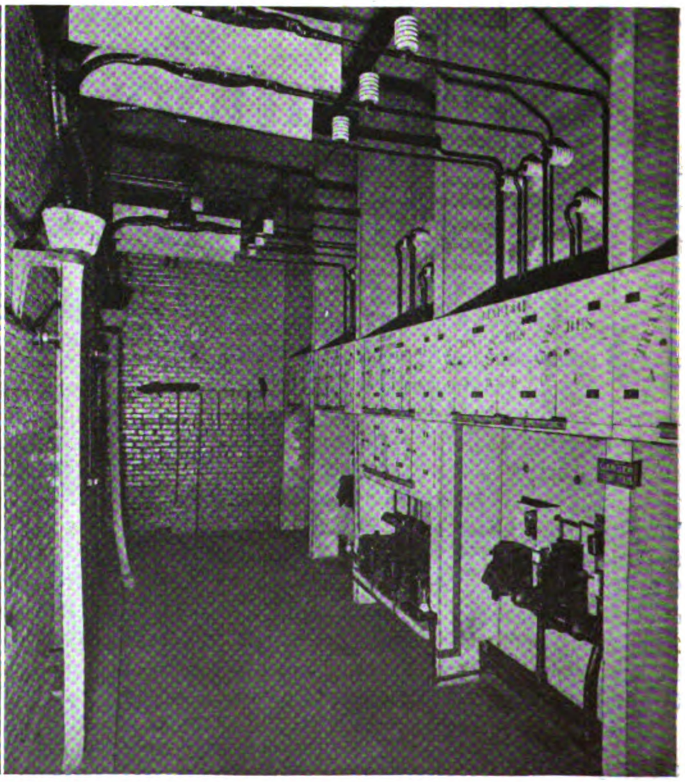
An interior view of the transformer room.

Incoming power is stepped down from 12,000 volts to 440 volts by these 1,000-kva., single-phase Pittsburgh transformers. Direct current for the oil switches is supplied from a storage battery and motor-generator set.



Switching equipment for the incoming 12,000-volt lines.

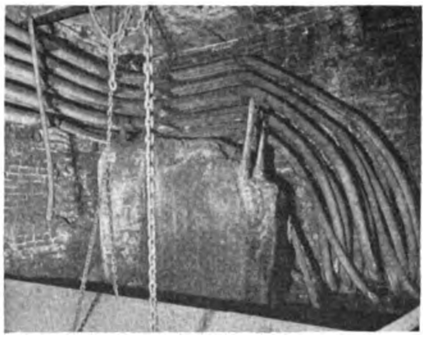
The incoming high-tension lines enter through the concrete ducts along the floor and extend up the wall at the left. The switching equipment is shown at the right. The front of the live sections is protected with Transite board.



The switching equipment on the incoming lines, the transformers and the switchboard are placed in three separate but adjoining rooms. Each has a separate locked entrance; the switchroom and transformer room, however, have a door between. Power is stepped down from the 12,000-volt, 60-cycle, three-phase incoming line to 440 volts by three 1,000-kva., single-phase, Pittsburgh water- and oil-cooled transformers. In case any transformer should fail, the two other transformers can be connected in open delta and will carry the load. Direct current for the Type F-10 Condit 25,000-volt oil switches is supplied from a Philco storage battery, which has its own motor-generator charging set. This set receives power from a 5-kva., 440/220/110-volt Pittsburgh pole-type transformer mounted on the floor in the transformer room. The lights for the switchroom are also supplied from this same pole-type transformer.

Transite board is mounted between the disconnect switches above the transformers, as may be seen in the illustration on page 150. The transformer room is ventilated by roof ventilators and louvres near the floor in the outside wall of the room.

The switching equipment on the incoming line is protected by phase-failure and reverse-phase relays and also has indicators to show which



At the end of the tunnel the lead-covered cables enter the underground vitrified tile ducts leading to the different buildings.

The tunnel is about 100 ft. long and the cables are carried through it on cast-iron wall brackets. In all exposed locations the cables are wrapped with hemp rope and covered with cement.

lines are working. An alarm system on both incoming lines and transformer breakers operates when any interruptions occur; the indicator shows which line is out. Another alarm system indicates when the transformer becomes too hot, due to water failure or other causes.

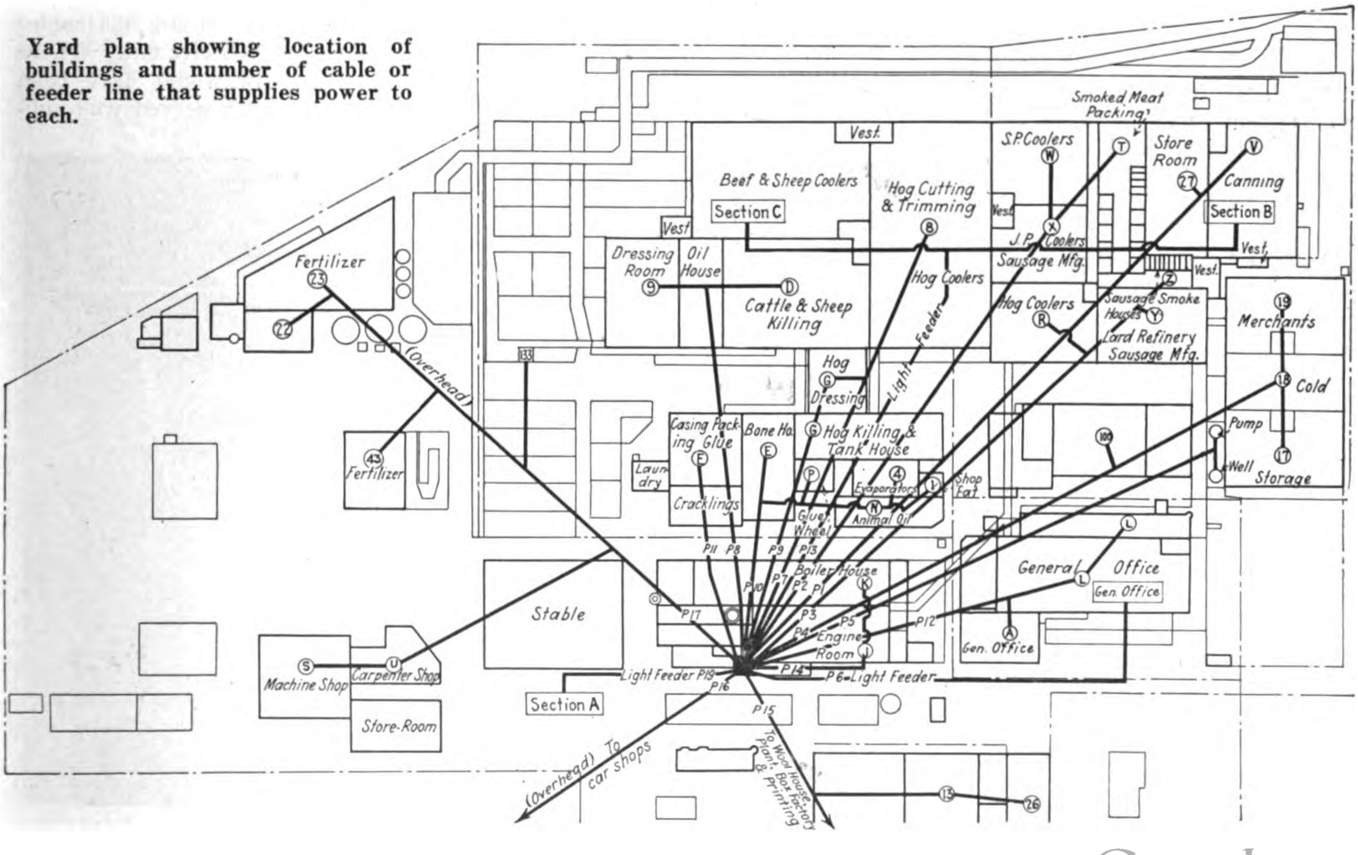
The switchboard is erected in a separate room adjoining the transformer room, but with no opening between them. The board has nineteen three-section slate panels, each feeding a building, department or group of equipment. Each panel carries a Weston indicating ammeter and a Condit Type E-4 oil circuit breaker either of 600-amp. or 800-amp. rating with oil dashpot overload relays with a current transformer on each outgoing leg of the three-phase line. An ammeter and an integrating wattmeter are connected into the main line. Also, a power factor meter is mounted on the instrument panel with provision made for plugging in any line to ascertain the power factor of that line. There is also a recording demand meter owned by the Commonwealth Edison Co.

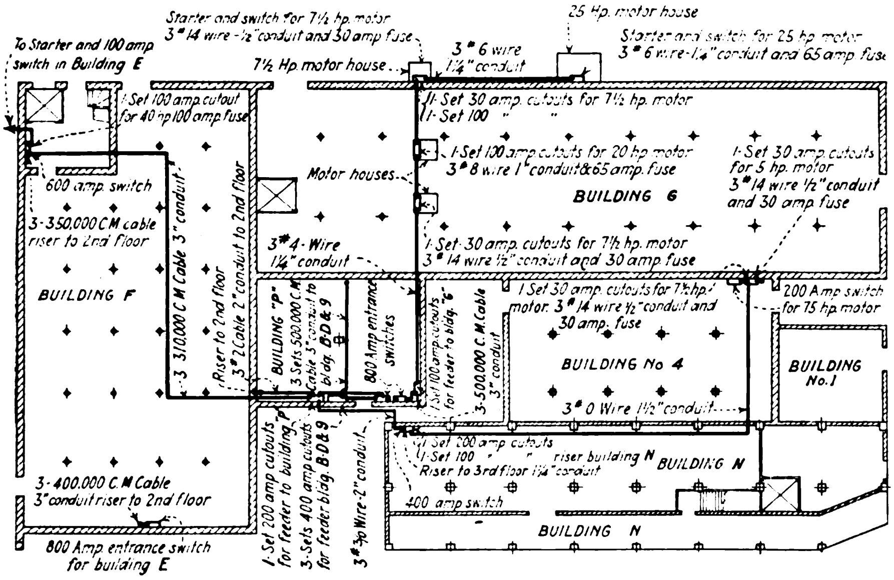
We are operating with a power factor of 83 to 85, which, we believe, is quite high for our industry. Our running load is about 3,400 amp. per phase, which is approximately 52 per cent of our connected load. The board is designed for a load of 4,500 amp. and is built with parallel buses. The cross-section of the copper decreases toward the end of the board.

We did not have space enough to extend the board in a straight line; so it is built in the form of three sides of a square, each side being practically parallel to the walls of an almost square room. All live parts of the board are mounted from 24 to 35 in. away from the wall, which gives the operators room to work safely behind it.

A careful study was made to determine the most suitable types of materials to be used, and from this analysis and past experience we tried

Yard plan showing location of buildings and number of cable or feeder line that supplies power to each.





Here is a ground floor plan of several of the buildings, indicating the location of power equipment.

to select what we thought was the best. The question of price did not influence our decisions, as we wished to select materials and equipment that would give us the best results from the standpoint of continuous operation and the least expense over a period of years. Delays are a very serious consideration in this industry, because each department is practically dependent on the others. Also, owing to the fact that the greater part of the product is perishable, a few shutdowns due to burnouts might entail the loss of many thousands of dollars. Always keeping this point in mind, we tried to guard against interruptions, and I believe we have accomplished much, if we are permitted to judge from the small amount of trouble we have had since the change.

Feeders from the board are carried down to the floor where they terminate in G & W (Electric Specialty Co.) potheads. These feeders are insulated with cambric tape between the switchboard and the pothead and continue therefrom as lead-covered cable through a tunnel carrying the underground lines, which will be described later in the article.

We selected Standard Underground Cable Co. underground, three-conductor, lead-covered, cambric-insulated cable for all underground work. Cables are laid in three-, six- or nine-conductor vitrified tile. As they come up at the end of the runs, the cables are fitted with G & W Type C underground cutout boxes, to seal them, and are led into VV safety switches. Simplex Wire & Cable Co. caoutchouc double-braid, rubber-covered wire was used throughout for all distribution to motors and control equipment.

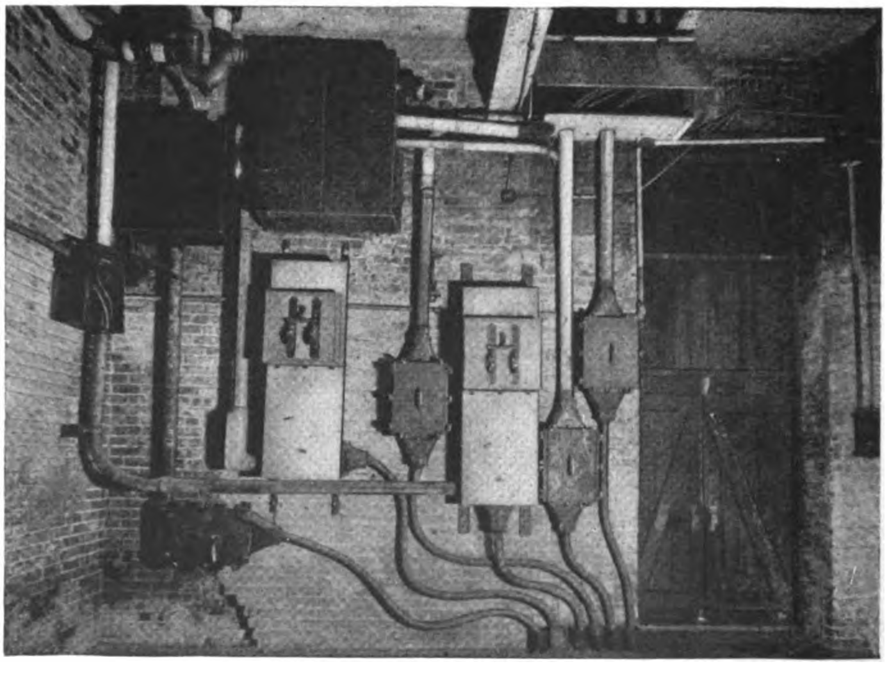
We did away with all direct-current load except about 500 amp. This is supplied by a 300-kw. Allis-Chalmers rotary converter. In case of emergency, this load can be shifted to either of two steam engines with direct-connected generators. All direct-current generating equipment is located in the old power plant and the power is distributed from part of the old switchboard. Direct current is used on some elevators, on coal-handling equipment and for charging the storage batteries for tractors. In the few other places where variable speed is necessary, slip-ring motors are used. Our stokers, for example, are driven by slip-ring motors.

In planning the distribution system the plant was divided into three groups of buildings with 20 individual circuits connected to corresponding panels on the switchboard. All circuits go out from the switchboard through a tunnel except two that are sent out on an overhead distribution line to the car shop and the fertilizer plant, which are some distance from the remainder of the plant. For these, the wires used in the old d.c. distribution system were in good condition and of the proper capacity, hence it was necessary merely to remove one wire, because with the d.c. installation we had separate lines for power and light to these groups. The present lighting circuits are fed in these two instances from a transformer mounted on a pole outside the buildings and supplied from the power line. No trouble is experienced with the lights dipping when motors are started, because the cables are large and there is unlimited generating capacity to serve them.

No distribution circuit has cables larger than 500,000 circ.mil. Where larger conductors would have been necessary, the area served was sub-

This shows how several of the underground cables are brought into one of the buildings.

The cables for this building are brought up through the underground conduit line into G & W outlet boxes to seal the ends. Type DF, VV safety switches are used here. One of the Transite board cabinets, which are used in extremely wet locations, is shown above at the left.



divided and two smaller circuits were used instead. Wire sizes on these twenty circuits vary from 300,000 circ.mil to 500,000 circ.mil by increments of 50,000 circ.mil. In the twenty circuits and their branches more than 200,000 ft. of wire and cable was used, varying in size from No. 14 wire to 500,000-circ.mil cables. All of these main circuits are carried in 2½-in. and 3-in. galvanized conduit with standard Crouse-Hinds fittings. Galvanized, instead of enameled, conduit was used because of the moisture and fumes from fatty acids encountered in this industry. The longest conduit run is about 500 ft.

The lead-covered cable runs in the tunnel are supported on horizontal cast-iron wall brackets spaced 3 ft. apart and carrying three cables on each arm. All cables in the tunnel as well as exposed parts in the manholes are rope wrapped and then covered with a coating of cement.

A number of distribution boxes were made of Transite board instead of metal on account of the moisture, ammonia and annimal fumes, and brine in the plant. Fuse blocks are mounted on slate panels. Economy refillable fuses are used. As stated, the lead-covered cable ends in G & W underground cutout boxes and then leads into the Type DF 400-, 600- or 800-amp. VV Fittings Co. safety entrance switches, which are used in the various departments on account of the moisture. In some locations where unusual amounts of acid and moisture are present Crouse-Hinds Type MK safety switches, which are housed in hot-dipped cast-iron covers, are used.

Motors in Bldg. E

Floor	Card #	H.P.	Duty	Marked
2	I-5	20	Expeller (East)	E-1
2	I-6	20	Expeller (West)	E-2
3	G-14	10	Crackling Mill. E	E-3
~~3~~	~~G-15~~	~~10~~	~~Crackling Mill. C~~	~~E-4~~
~~3~~	~~J-17~~	~~25~~	~~Glue Breaker~~	~~E-5~~
4	G-16	10	#5-Melter	E-6
4	G-17	10	#4-Melter	E-7
4	G-18	10	#3-Melter	E-8
2	J-18	25	Expeller (New)	E-9
~~6~~	~~D-10~~	~~½~~	~~Sewing Mch.~~	~~E-10~~
Roof	L-2	35	Frict. Elev.	E-11
2	G-24	10	Glue Rolls	E-12
2	F-22	7.5	Fan	E-13
2	O-2	55	Fan.	E-14
1	M-4	40	Glue Pulverizer	E-15
1	A-49	1/5	Fan. Blood Albumen	E-16
Roof	F-37	7.5	Entrail Cutter	E-17
4	G-42	10	#6-Melter	E-18
3	G-44	10	Glue Breaker	E-19
3	G-44	10	Mill	E-20
4	G-46	10	#7-Melter	E3-12
4	H-29	15	#1 & 2 Melter	B-19
3	G-8	10	#3-Mill	G-8
5	E-63	5	Washer	E-21
Roof	H-12	50	Jeffry Hasher	E-22
2	I-13	20	Expeller. E.end	E-23
2	I-14	20	Expeller. W.end	E-24
~~2~~	~~E-48~~	~~15~~	~~Blower~~	~~E-25~~
4	E-49	15	#8-Melter	E-26
4	E-50	15	#9-Melter	E-27
4	E-51	15	#10-Melter	E-28
4	E-52	15	#11-Melter	E-29
2	J-31	25	Blower	E-30

This is the loose-leaf record of the motors in one building.

A double record is kept on every motor. This record shown here is kept according to location and shows not only the card number of the motor (second column) but also the identification or stenciled marking (last column). When a motor is moved or changed, the entry is crossed out in this building location record and a new entry made for the new motor. The number and the identification mark of the motor are never changed. A separate page is kept for each building in the plant.

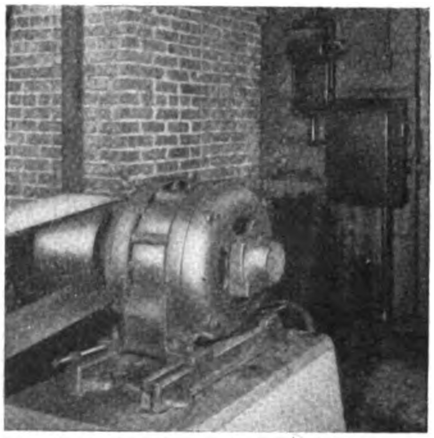
The lighting service is taken from 16 440/110-volt Moloney Electric Co. Type T lighting transformers located in the various buildings in brick vaults with concrete floors. We do not use a neutral wire but carefully balance up the loads on the different phases.

In the coolers where the warm carcasses are brought from the killing floor to cool, the ceilings and walls are dripping with moisture. In such cases we could not use conduit, because it would soon fill with water. We spent a good deal of money and time trying to get a conduit installation that would stand up, but could not keep it free from grounds. Finally we received permission from the city inspectors to use open wiring supported on Universal porcelain insulators mounted not more than 5 ft. apart and placed along the side of the ceiling beams. Wherever it is necessary to cross over on the lower side of the beam, the wiring is protected with Transite board. Transite cutout boxes are used in such damp locations.

The change-over was made a floor at a time and was all done without interruption to plant operations. The substation and underground conduit runs were put in first. New conduit runs to the motor and control equipment on a floor were then installed and at the first opportunity each old motor was removed and the new one put in its place and connected up.

In a large majority of the cases the new motor was placed on the old platform or on a new platform which replaced it. Overtime work was necessary on some of the changes, although in many cases we were able to find a motor idle for sufficient time to make the exchange. Change-overs on the killing floors were made on Sunday.

The entire job was completed in 13 mo. During this time the average number of men employed was 40, at times more, depending upon the activity. This number includes the laborers, carpenters, electricians, and so on. The carpenters were employed



One of the induction motors, and its control.

This is a 50-hp. Allis-Chalmers Type AR motor driving a hasher through a rubber belt. The motor is controlled by an Allis-Chalmers Type R starter. Connection to the power line is made through a Crouse-Hinds hot-dipped, cast-iron safety switch. The motor is mounted on a concrete base to protect it from the water that is used to wash out the room.

to rebuild motor platforms, cut and build partitions, construct the concrete forms and perform other woodworking operations. In a number of cases new motors were inclosed in separate rooms or were separated by partitions from the remainder of the department, where operating conditions are bad.

Since the change-over we have had failures of only three 7½-hp. and three 3-hp. motors. This does not include one 50-hp. motor failure caused by a laborer shoveling cinders into it to keep the belt from slipping. This record is not only due to the new equipment which has been installed but also to our method of inspection and care, which will be outlined later.

Almost all induction motors of 10-hp. or more are Allis-Chalmers Type AR. A large number of these are controlled by Allis-Chalmers Type R starters. Some Industrial Controller automatic starters are used where push-button control is necessary. Across-the-line starters are used on all motors up to 5 hp. Almost all of these small motors are of Crocker-Wheeler make. Slip-ring motors are controlled by Cutler-Hammer drum-type, non-reversing controllers with auxiliary contacts to interlock with the primary oil switch.

In many cases motors are built into the machine, as, for example, on some presses driven by specially designed 20-hp., Type FTR General Electric motors. These are controlled by General Electric Type CR-7076 DS-5 magnetic switches. An indicat-

ing ammeter is connected into one power line to show whether the machine, which is totally inclosed, is feeding. Otherwise the press might operate for a considerable time after it was empty, or with a stoppage in the feed line. A fluctuation in the power used, as shown by the ammeter, indicates a variation in the amount of the load, which is, of course, controlled by the feed to the machine.

Some of the older equipment is operated in group drives. However, many of the new machines that are being added are individually driven through belts, gears or chains, or are direct connected, as is considered best under the circumstances. One battery of melters, for example, is driven by 15-hp. motors through Link-Belt silent chains.

We have 35 General Electric synchronous motors which vary from 35-hp. to 100-hp. rating. These are used on friction elevators, some of the centrifugal brine pumps (others are turbine driven), centrifugal water pumps, air compressors and lard hashers. All synchronous motors have direct-connected exciters and are controlled by General Electric Type CR 1034 hand-operated starters. The synchronous motors are operated at either 80 per cent leading or unity power factor.

Although these synchronous motors are largely responsible for the satisfactory power factor, every effort is made to see that all motors are operated at as near full load as possible. When ordering a motor for a drive, a great deal of care is taken to see that it will be fully loaded. For example, on one battery of individually driven machines we found that 15-hp. motors would operate satisfactorily instead of the 25-hp. motors that had been recommended. In practically all cases a machine manufacturer will recommend a motor of such size that it will take care of the greatest possible overload that can be placed on the machine under any conditions. The operating conditions in a particular plant may, however, be such that this extreme load will never be imposed. Advantage can be taken of this condition when ordering the motors.

D-34 No. 1,2 & 3 Ice Tank Circulator
General Elect. Co. synchronous motor
No. 4018275-1S350076-12, Type ATI-6-37½
Amp. 49, Form PB., H.P. 35, Power factor .8
Three-phase, speed 1,200, Amp. field 9.5, Cycles 60.
Volts 440, 50° C. cont. Marked B-14
Pulley 10" diam. 10" face., 2½ " bore
5/8" Keyseat and setscrew.
Brushes 1½" x 7/16" x 7/16". 3½" shunt.
3/16" sleeve term. Bearing #192444, pulley & front end.
(Over)

Exciter
D.c. generator #253274, frame 2, Type EF, Form E
1S350042-1. Amp. 12, speed 1,200, volts no load 125, full load 125. Kw 1½. 50° C. cont.

Sample card record of a synchronous motor.

The card number of this motor is D-34 and it is marked B-14, which indicates that it was originally installed in Building B. All motor data are contained on this card. In case a complaint comes in to the Chief Electrician's office, the foreman of the department would report trouble with the motor on Nos. 1, 2 and 3 ice tank circulator. Reference to the loose-leaf location record would identify the motor and all data would then be obtained from this card. Any trouble in operation and changes are recorded on this card.

Today we have practically no trouble in connection with the operation of the 550 motors, varying from ⅛-hp. to 200-hp. rating, in addition to the 35 synchronous motors required to operate the plant. This equipment is inspected daily and maintained over 24-hr. service. All necessary routine duties, as well as new work and changes, are handled by a force of eleven men working on a six-day schedule, although seven-day operation is required.

Of this gang, one man is in the office at all times to receive telephone calls and another stays in the shop. In addition, a trouble man with headquarters in the shop is on call to answer any complaints on service interruptions, to replace fuses or lights, and so on. The daily inspections require the services of three route men. In addition, two night electricians, one for each night shift, make their headquarters in the power house, where they have telephone service.

The remainder of the gang, with a working foreman, do any necessary new work or alterations. All work involving changes or new construction estimated to cost not more than $100 is done upon the requisition of the superintendent of the department involved. Some time ago this limit was raised from $25 to $50 and recently to $100, which has simplified the work in connection with the many small tasks involved.

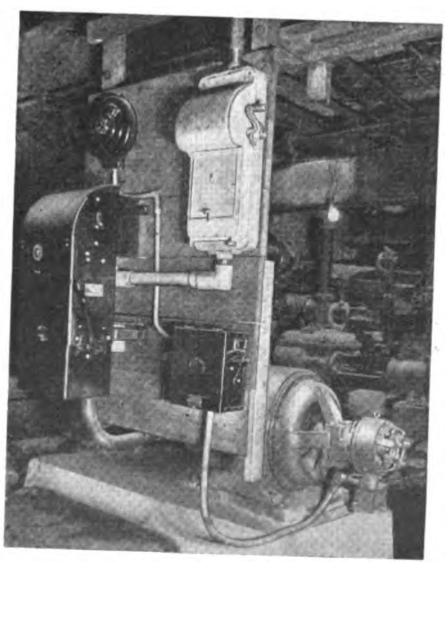
Whenever a motor is to be idle for any length of time, we coat the windings with a good insulating paint, and paint the frames gray with a mixture of lead and oil put up in our paint shop. In some cases where considerable acid is encountered we use No-Ox-Id, a grease paint or rust preventive compound manufactured by the Dearborn Chemical Co., which we have found to be very satisfactory. We also use this grease on all hold-down and belt-tightening bolts on our motors. In addition, we blow out the motors on a regular schedule with compressed air.

Each motor is given a daily inspection by the route men; the oil rings and oil level are examined, and the switch and starting equipment inspected. The inspector also notices whether condensate is dripping from the ceiling to the motor.

Whenever a fuse blows, the trouble man replaces it and checks it on his trouble sheet. The route man watches the installation and at the first opportunity tests the fuse rating and adjusts the overload relay, if necessary, to prevent single-phasing. We find that by keeping the overload relays set as close as possible to the required running load we can eliminate the possibility of single-phasing.

A record is kept of every motor both by location and motor number. The location record is kept by buildings and floors in a loose-leaf book with a page or more devoted to each floor as necessary. This record shows building number, floor, card number

(Please turn to page 159)



One of the 35 synchronous motors and its control.

This 100-hp., 1,800-r.p.m. General Electric synchronous motor drives a 2,500-g.p.m. Allis-Chalmers centrifugal pump. The motor is self-excited and operates at 80 per cent leading power factor. It was necessary in this case to suspend the control apparatus from the ceiling because of space limitation. The 440-volt feeder is brought into a Type MK Crouse-Hinds safety switch with hot-dipped, cast-iron housing. The motor is controlled by a General Electric Type CR-1034 hand-operated starter with push-button stop.

Operating Characteristics of

Horizontal Quarter-Turn Belt Drives

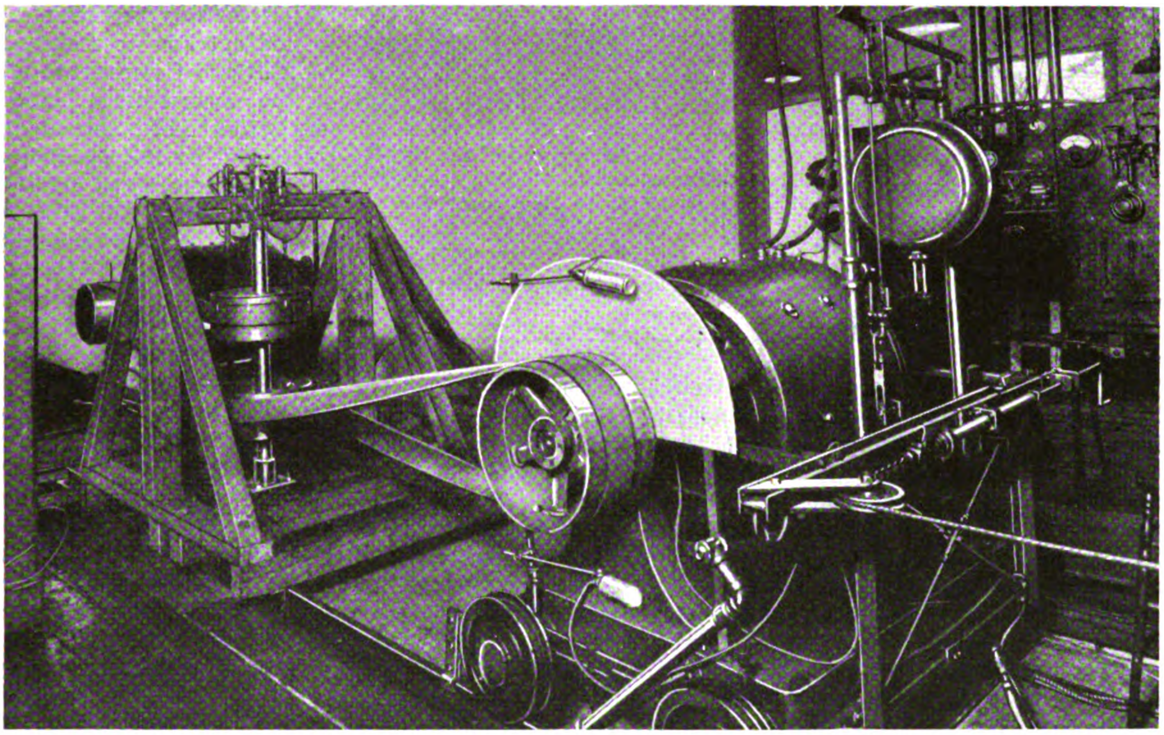


Fig. 1—The driven end of the testing dynamometer.

The belt in the foreground is under test and is driven at a quarter-turn from the vertical countershaft. This equipment measures slip, tension and horsepower transmitted.

By R. F. JONES

Research Engineer, The Leather Belting Exchange Foundation

Cornell University, Ithaca, N. Y.

IN ITS research work the Leather Belting Exchange Foundation has made extensive studies concerning the effect of the operating or service conditions on the power-transmitting capacity of leather belts. Results of three previous series of tests have appeared in INDUSTRIAL ENGINEER. The first of these reports* gave the results of tests made to determine the effect of diameter and ratio of pulleys, center distance, high belt speed, and the use of the gravity idler on horizontal belt drives. The information obtained was put in the form of curves and tables in order that it might be used in laying out horizontal belt drives operating under the above-mentioned conditions.

The next report made comparative studies on the angular or inclined drive and the horizontal belt drive and gave additional data with correction factors to use in connection with data previously published. A third article contained the report on tests made on crossed-belt drives. A table of maximum center distances on such drives and other important transmission data to be considered when making such installations was included.

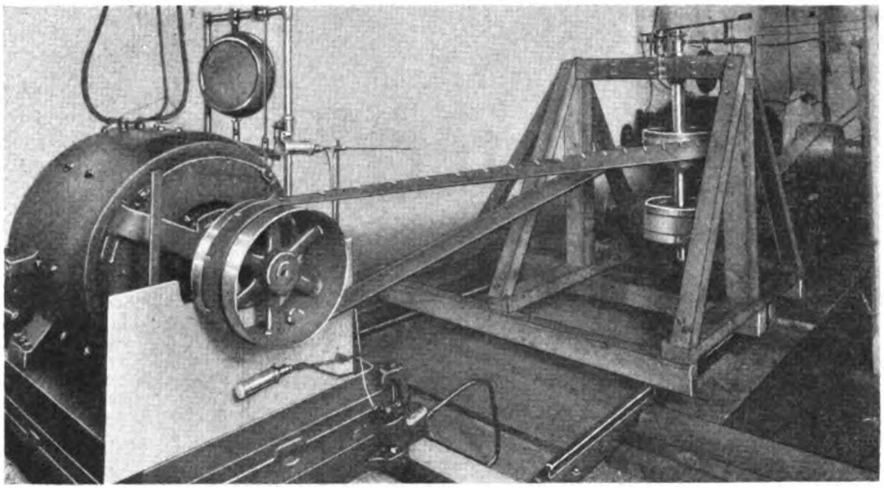
Additional studies, which have been made recently on the operating characteristics of horizontal quarter-turn leather belt drives, are used as the basis of this article.

The object of these experiments was to study the transmission capacity of horizontal quarter-turn drives, as compared with normal horizontal drives, and thus establish a more correct basis of design for such drives. Another object was to try out certain combinations of pulleys and center distances in the hope of learning more about the practical layout of quarter-turn drives.

Primary considerations in the design of the quarter-turn apparatus were: measurement of horsepower transmitted, measurement of slip, measurement of initial or slow running tension, flexibility in the use of pulley sizes covering a range from 6 to 30 in. in diameter and center distances ranging from 5 to 15 ft., and ease in converting the apparatus from the normal drive to the quarter-turn drive or vice versa.

A general layout of the equipment used is shown in Fig. 1. The

*These three reports were published in articles that appeared in INDUSTRIAL ENGINEER in June, 1925; April, 1926, and June, 1926. Readers not having copies of these issues on file may obtain the information on which these three articles were based by requesting copies of Reports R-13, R-14, and R-15 from the Leather Belting Exchange Foundation, 417 Forrest Building, Philadelphia, Pa.—EDITORS.



driving dynamometer of our 100-hp. belt-testing apparatus was employed to drive a vertical countershaft through a quarter-turn belt (left-hand belt in Fig. 1), and the countershaft drove the absorbing dynamometer through the test quarter-turn belt (right-hand belt in Fig. 1). The driven dynamometer (at right in Fig. 1) was mounted on a track and so could be moved back and forth to allow a variation of center distances from 5 to 15 ft. on the test drive. The tension was weighed on the tension scale as usual. The tension scale is attached to the right-hand end of the steel cable that runs off the right edge of Fig. 1. The frame for the countershaft was bolted solidly to the track at a convenient distance from the driving dynamometer.

It will be noticed from Fig. 1 that the countershaft is supported at the bottom by a step bearing and at the top by an ordinary vertical bearing. These bearings were mounted on sliding bases that allowed a sidewise movement of 14 in. in the countershaft to accommodate pulleys up to 30 in. in diameter. This was necessary because the center of the lower pulley on the countershaft had to be in a horizontal line with the center of the lower face of the pulley on the absorbing or driven dynamometer.

The countershaft constituted the driving unit of the test drive, and therefore the contactor end of the slipmeter was attached to the upper end of this shaft, as shown at the top of Fig. 1. The rotating lamp of the slipmeter was mounted as usual on the absorbing dynamometer shaft, and its rotations measured the slip of the belt between the countershaft and this machine.

The illustration, Fig. 2, which was taken from the driving dynamometer end of the test equipment, gives a good view of the quarter-turn drive that supplied the power. A heavy double belt was used to furnish steady power at the jackshaft with little slip. The driving dynamometer pulley had to be in line with the inside edge of the upper countershaft pulley. For each pulley change the countershaft was moved to bring the lower countershaft pulley into line, and therefore the driving dynamometer had to be moved to keep it in line with the upper pulley. This dynamometer was mounted on slotted rails that were long enough to allow sidewise movement.

Fig. 2—The driving end of the testing dynamometer.

This motor drives the countershaft through a heavy double belt with very little slip. To make normal horizontal drives, the vertical countershaft was removed and the two dynamometers connected direct with the belt under test.

To change the apparatus back to the proper position for the normal drive tests, the countershaft was removed from its supporting frame, and the driven machine and tension scale carriage were moved up to give the proper center distance. The driving dynamometer was then moved to the left until correct pulley alignment was attained. At short-center distances the whole countershaft frame had to be moved from the track.

The power transmitted by the test belt to the driven dynamometer was fed back to the line, thus reducing the power consumption of the apparatus about 60 per cent.

An important feature in comparative belt tests is the use of belts representative of the different conditions of surface and elasticity found in normal service. In the present case, one leather belt possessing a normal, high-friction surface was chosen as representative of leather belts at their best. Another leather belt having a buffed grain surface represented the class of belts the coefficient of friction of which has become reduced through lack of care or misuse. A third belt, known to be still lower in transmission characteristics and very constant in surface conditions, was selected to represent ability. These three belts with their dimensions are listed in Table I.

The first transmission comparison between the quarter-turn and normal drives was largely an experiment to find out how to make such tests. Belts B and C were carefully run in on the normal drive before making any tests. Then normal drive tests were made on 18-in. cast-iron pulleys on 13-ft. centers and driven to give a belt speed of 2,000 f.p.m. with the belt under a slow running tension (s.r.t.) of 288 lb. As soon afterward as the apparatus could be converted to the quarter-turn drive the belts were put on the test quarter-turn drive and tested under the same conditions. The resulting Horsepower vs. Per Cent Slip Curves, given in Fig. 3, show the normal drive to be superior in each case. However, something appeared to be wrong especially with Belt C because with this type of belt the two curves were widely apart during the creep region, which usually extends up to 1.5 per cent slip or more. Since creep is dependent upon the tension arrangement in the two strands of the belt and the elastic properties of the belt, the curves should have been closer together than they were below 1.5 per cent slip.

It is probable that this effect was due to the omission of running in before testing on the quarter-turn drive, which gave the belts no opportunity to conform to this drive. It was omitted because running in between the sets of comparative tests might have changed the belt surface and in that way destroyed the accuracy of the tests. Another possible source of error was due to the fact that as a leather belt is run in on a normal drive it improves more rapidly in the center, which results in a lower coefficient of friction at the edges than in the center. When this belt is put on a quarter-turn drive, the leather at one edge is under more tension than that in the center or on the other edge, and therefore the real intimate contact between belt and pulley, which does the pulling, takes place on one of the edges, which has a lower coefficient of friction than the center.

As a remedy for these two causes of error, we tried running in the next belt and testing it on the quarter-turn drive first. No running in was done before the normal drive test, and the belt seemed to conform to the pulleys even after being stretched out of shape by the quarter-turn drive. This was Belt A, curves of which are plotted in Fig. 4. It will be noticed that the creep lines of the two tests almost coincide and that the normal drive is a little better at high slippage. In view of these results, the latter method of test was adopted for the remaining tests.

In order to check this conclusion again and secure more accurate results with the first two belts, the tests on Belts B and C were repeated, making the quarter-turn drive tests first as with Belt A. The horsepower-slip curves for each belt, plotted from these tests in Fig. 5, are much closer together at the lower slips than in the first tests shown in Fig. 3.

Up to this time the comparison between the two drives had been made at the rather liberal center distance of 13 ft., which was chosen to bring the quarter-turn drive well within the range of good practice. It is obvious that the angle at which the belt leaves both pulleys of a quarter-turn drive becomes greater as the center distance is shortened. As a result the strain on the long edge, which takes most of the load, is increased as the center distance is decreased. Other tests at a shorter center distance bordering on the lower limit of good practice were necessary. Following the empirical rule that the center distance of a quarter-turn drive should be at least five times the diameter of the larger pulley, a center distance of approximately 7 ft. 6 in. for the 18-in. pulleys was chosen for the next tests.

Table I—Types of Belts Used in Quarter-Turn Tests

Belt	Material	Width, Inches	Thickness, Inches	Weight, Oz. Sq.Ft.
A	Single leather, buffed grain	4.00	0.205	15.3
B	Unidentified	3.92	0.195	17.2
C	Single leather, normal grain	4.04	0.221	16.3

The two leather belts A and C, after being cut to the proper length, were put on this short quarter-turn drive, run in and tested, after which the normal drive comparisons were made. The tests on Belt C followed each other directly, except for an interval of time required to change over the apparatus. As more time elapsed between the two tests on Belt A, with a greater possibility of error due to humidity or surface changes, the quarter-turn apparatus was set up again and another test was made on this drive. These are indicated as curves 3, 4 and 5 in Fig. 6; curve 5 is the extra test. This completed the power transmission comparisons of the two drives.

A number of trials on different combinations of pulleys and center distances were made in an effort to find out if there are any limiting conditions of a mechanical nature in the layout of quarter-turn drives. Practically any drive that could be duplicated on our apparatus would work, although at short center distances a terrific strain was obviously put on the long edge of the belt. In some of these short drives using a small pulley, the short edge of the belt was not in contact with this pulley at all. Instead it tended to curl away from the small pulley because of the crimping action due to the sharp lateral bend as the belt left the pulley. Obviously the life of the belt on such a drive would be very short, so short that belt life is really the determining factor in the use of such drives.

An examination of the horsepower-slip curves in Figs. 3, 4, 5 and 6 reveals that with one or two exceptions the normal drives transmitted more power than the quarter-turn drive. In all tests except those shown in Fig. 3 the power transmitted at slips less than 1.5 per cent was approximately the same for each drive. (It will be remembered that the curves in Fig. 3 are not considered so reliable as the others because the belts were not run in and therefore had not conformed to the quarter-turn drive before the tests were made.) At slippages beyond 1.5 per cent the curves separate and the small superiority of the normal drive is evident except in the case of Belt B in Fig. 5.

The horsepower figures in Table II were taken from the curves by using a piece of finely scaled cross-section paper beneath the originals. Values of the horsepower transmitted by the normal and quarter-turn drives and the difference in percentage between the two are given at 2 and 3 per cent slips for each comparison shown in Figs. 3, 4, 5 and 6. There is so little difference between most of the curves at 1.5 per cent that a tabulation of these data is considered unnecessary.

In computing the percentage difference for Belt A at 7 ft. 6 in. center distance the averages from the two curves 3 and 5 of Fig. 6 were used to compare with the values from curve 4 as indicated in Table II. The greatest difference between the two drives occurred with the high-capacity Belt C at 3 per cent slip, the difference being 16.9 per cent at 13 ft. center distance and 23.4 per cent at 7 ft. 6 in. center. It will be noticed that at 2 per cent slip the percentage differences for Belt C are much less, omitting the uncertain

Fig. 3—Tests made on two belts of high and low power-transmitting capacity.

The wide difference between the curves of the same belt up to 1½ per cent slip indicated that the belt had not been allowed time enough to conform to the quarter-turn drive.

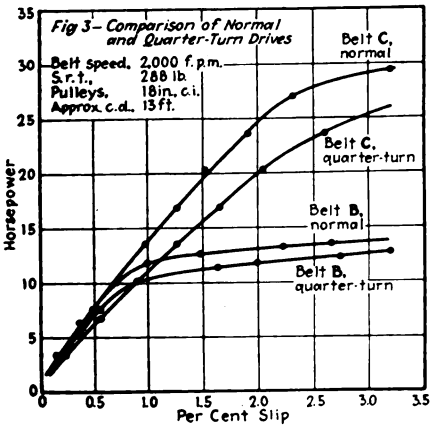


Fig. 4—Test data on the buffed leather belt after it had been broken in.

In this case the transmitting capacity of the belt up to about 1½ per cent slip was practically the same on both the quarter-turn and normal drives.

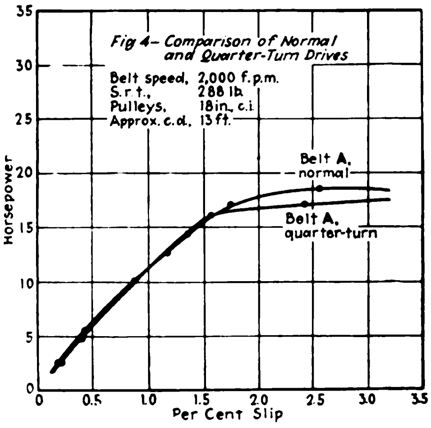


Table II—Comparison Between the Transmitting Capacities of Quarter-Turn and Normal Drives

			2 Per Cent Slip			3 Per Cent Slip		
Fig. No.	Belt	Center Dist.	Horse-power, Normal	Horse-power, Q.T.	Diff., Per Cent	Horse-power, Normal	Horse-power, Q.T.	Diff., Per Cent
3	B	13	13.2	11.8	10.6	13.8	12.7	8.0
3	C	13	24.9	19.9	20.0	29.3	25.3	13.0
6	A	13	17.7	16.6	6.2	18.4	17.3	6.0
5	B	13	13.3	14.0	—5.25	13.7	14.3	—4.4
5	C	13	22.9	22	3.9	32.5	27.0	16.9
6	A	7.5	17	17.2	Av.=0	19.0	19.2	Av.=3.15
6	A	7.5	17	16.8		19.0	17.6	
6	C	7.5	21.1	19.5	7.6	32.5	24.9	23.4

value from Fig. 3. With Belt A, the belt of medium capacity, the differences are small and they are greater at the longer center distances. The results from Belt B, the belt of lowest capacity, indicate very little difference betwen the two drives; in one case the normal drive horsepower is higher and in the other case it is lower than the quarter-turn horsepower, with average slightly in favor of the normal drive.

The following conclusions may be drawn from the table and curves. First, at slips up to 1.5 per cent there is practically no difference in the transmitting power of the two drives. Second, at the higher slips the advantage is with the normal drive, especially with belts of high capacity. Third, if the center distance is within the limits of good practice, it has little if any effect on the difference betwen the two drives or, in other words, center distance has no effect on this difference unless it is so short that the belt does not conform well to the quarter-turn drive.

For the purpose of design a horizontal quarter-turn belt should be from 5 to 10 per cent wider than a normal belt, other conditions remaining the same. Under most conditions an allowance of 5 per cent would be enough, but if the drive is severe, 10 per cent would be better. It is not certain that these figures would apply to a belt much wider than 4 in., but they should apply if the belt conformed well to the drive and was in good contact with the pulleys most of the way across the belt.

There is no theoretical reason why a quarter-turn belt should not be able to carry as much load as a normal belt, except that the tension varies across the width of the belt. The total area of pulley contact is certain to be less because the short edge is not in good contact at certain points, but theoretically this should make no difference; practically it may have some effect. Furthermore, the effective arc of contact is actually greater on a quarter-turn belt than on a corresponding normal belt. A glance at the driven dynamometer pulley shown in Fig. 1 will explain this.

It is true that the short edge of the belt does not come on the pulley as soon as the long edge, and in fact it may not touch all of the way around, but it is also true that the edge that is carrying the load makes contact with the pulley throughout the entire theoretical arc of contact, which is always greater than 180 deg. on both pulleys. Therefore the small differences indicated by the tests on the low-capacity belts are to be expected. The greater difference obtained at high slippage on Belt C can be partly explained by the fact that this belt undoubtedly had a better coefficient of friction in the center than on either edge, where most of the contact on the quarter-turn drive came.

In the trials of different quarter-turn drives the lengths of the long and short edges of several were measured by placing a steel tape immediately alongside each edge of the belt. The difference in length of the two edges varied from 13/16 in. to 3 in., the latter being the difference for a 30-in. pulley driving a 6-in. pulley at 6-ft. centers. This is an impractical drive, but the belt stays on, although the short edge was curling and crinkling badly as it left the small pulley. A 9-in. pulley was substituted for the 6-in. pulley, but it did not improve conditions much. At longer center distances, five times or more the diameter of the larger pulley, the long edge of a 4-in. belt would not be more than 1½ in. longer than the short edge.

The difference in length of the two edges is caused by the fact that the same edge has to take the outside of the curve formed by the belt as it leaves either pulley, and the stress is usually greater on that part of the belt passing through the curve at the driven pulley. The shorter the center distance for any given pulley the sharper this curve and the greater the strain on the belt. Since the curvature depends upon the pulley diameter and center distance, their ratio determines the maximum bend the belt will have to make (which will be on leaving the smaller pulley). It follows, then, that this ratio has an important influence on the life of the belt. The fact that belt life is an important factor in the choice of the minimum ratio betwen the center distance and the large pulley diameter brings in an economic problem that can be more easily solved by a study of quarter-turn belts in service than by a laboratory study.

A few remarks on points of general interest in the operation of

Fig. 5—Comparative transmitting ability of two different types of belting.

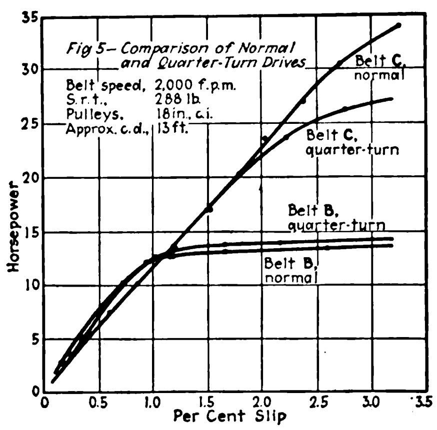
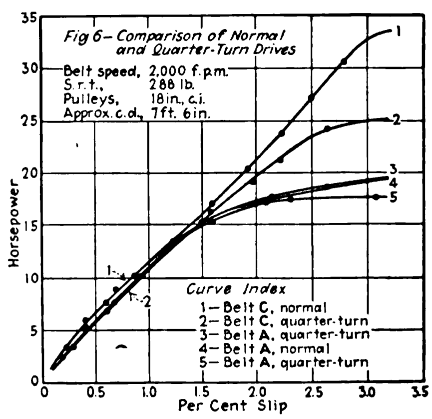


Fig. 6—Results of tests on leather Belts A and C operating with short center distances.



quarter-turn drives might be of some value in this discussion. In almost every instance where a leather belt was installed fairly tight, a certain amount of squeaking was present even at no load. This was caused by the tendency of the belt to slip sideways just before it left the pulleys. If the belt was under load, the squeak usually originated at the side where the belt left the driven pulley, because this was the tight side and naturally offered more resistance to sideways sliding than the loose side. In the case of the 30-in. pulley driving the 6- and 9-in. pulleys at 6-ft. centers, the side slipping was great enough to cause bad heating of the smaller pulley.

In general, a quarter-turn belt will stay on the horizontal pulley better when it is used as the driver, because if it is driving, the loose or sagging strand of the belt comes on to the driven pulley, which is in a vertical plane, and therefore the belt will run true regardless of the sag of the loose side. If the driver pulley is in a vertical position, the loose side of the belt feeds on the horizontal pulley and the sag of this strand tends to make the belt run off the lower side of the pulley. When the load is variable, the belt has a tendency to run in a different place on the horizontal pulley for every change in load. Tightening the belt helps to overcome this trouble, which would be experienced more with loose belts that are operated at long centers or at high speeds.

Briefly, some of the more important results and conclusions drawn from these tests on quarter-turn belts are as follows:

1. For the purpose of design a horizontal quarter-turn belt should be from 5 to 10 per cent wider than a normal belt operating under the same conditions. There is very little difference in the transmitting capacity of the two drives at slips below 1.5 per cent and more or less difference at higher slips, depending on the belt.

2. The difference between the capacity of normal and quarter-turn belts at normal slips is probably small at any reasonable center distance above the minimum that is used (five times the large pulley diameter).

3. Any quarter-turn drive that can be duplicated on our testing apparatus will run—that is, the belt will stay on at least for a time and transmit power. Therefore the limiting mechanical conditions, such as the ratio of the larger pulley diameter to the center distance, should be determined by other considerations.

Changing Distribution System

(Continued from page 154)

of motor, horsepower, duty (machine it drives) and stencil identification or motor marking. One of the pages from this record book is shown in an accompanying illustration. For example, the key letters or figures in the stenciled marking identify the building; this is followed by a number identifying the particular motor. Thus, in Building K the motors are stenciled K-1, K-2, and so on. Some buildings go by numbers, and here the motors are identified, as in Building 16, by the number 16-1, 16-2, and so on. The motor always retains this number, even though it is moved to another building.

Motor data are recorded on a 3x5-in. card. This is filed by card number and carries the nameplate data, pulley size, key dimensions, bore, marking on motor (stencil number) and manufacturer's number of bearing or bearing size. One of these cards is also reproduced here. Any necessary repairs, trouble or changes in location are recorded on the back of the card. When a motor is moved, the number of the new motor replacing it is substituted in the loose-leaf building record. A corresponding change is made in the loose-leaf record when this motor is again put into service either in that building or some other.

Although the amount of repair work necessary on our a.c. equipment would be very much less than in the case of the d.c. equipment which we formerly had, our requirements and operating conditions are so severe that we can maintain the high operating standards which we have set only by constant vigilance.

After installation, a test is made with an Esterline graphic meter on all new motors and the chart is filed away for reference. Should we desire at any time to put an additional load on any particular motor, it is not necessary to make another test to find out how much we can add. This test record is always available. However, if an additional load is put on any motor, a new test is taken and the old record destroyed or placed in a dead file for reference.

An example of the good service we are getting from our equipment is in connection with a 10-hp. Allis-Chalmers motor drive on a hot beef chain. This carries the freshly killed beeves past the butchers, who perform various operations on the carcasses before they pass into the cooler. The motor driving the chain starts under load and is operated by an Industrial Controller compensator from a push button. Conservatively, this motor is started and stopped more than 100 times a day. During the past 2 yr. it has been necessary to renew only two contacts. This service is due to the careful daily inspections of the equipment.

Although a large amount of work was involved in making the changeover from direct to alternating-current power, we are sure that it has paid not only from the standpoint of reduced maintenance but, what is more important, in the elimination of breakdowns and interruptions to service.

One Way to Obtain Constant Spray Density

MAINTAINING a spray of constant density is a difficult problem. The greatest trouble is from clogging of the nozzle. Another source of trouble is due to changes in the density of the liquid, particularly with a lowering of temperature. Also, these troubles increase with the fineness of the spray required.

In one plant a spray as fine as the finest mist was required. The operating department had about given up the problem because it could not be sure of maintaining a spray of constant fineness; variation in density would have been fatal to the product.

The Master Mechanic finally evolved a plan that eliminated the nozzle and gave the fineness of mist wanted. This plan consisted of directing a high-pressure stream against a metal plate. In place of the nozzle the liquid was discharged from the open end of a small pipe. Of course, the liquid spattered and most of it ran down and off the plate, but this was collected and pumped back against the plate. However, above this spattering a constant mist arose that was finer than anything that had been produced before. The necessary arrangements were made to have the material to be treated exposed in this mist, and the most important troubles of the operation were over.

Uses of

Electric Drills

in Maintenance and Repair Work

By EDWIN L. CONNELL

Chief Engineer,
The Van Dorn Electric Tool Company,
Cleveland, Ohio

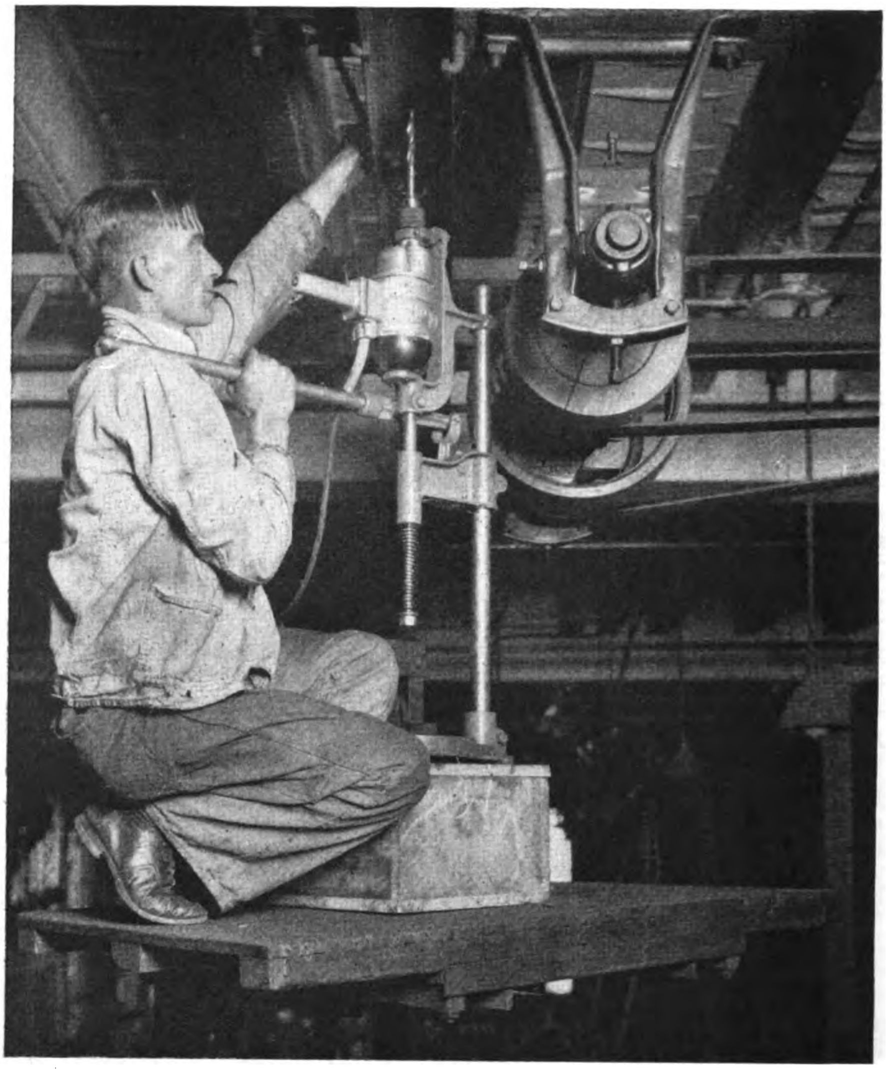


Fig. 1—Drilling holes in the ceiling is easy by this method.

The stand shown in Fig. 2 is mounted on the platform of an elevating-platform, electric industrial truck and then raised to the ceiling. The feed while drilling is obtained by the lever on the drilling stand.

EVERY man responsible for maintenance knows the value of any equipment which will enable him to drill holes quickly and easily in the most unusual and inconvenient places and through the greatest variety of materials. The electric drill is a most useful tool in the equipment of the modern maintenance man, whether his work be in a steel mill, a textile mill, a mine, or skyscraper.

Let us consider holes in metal, or more specifically, in mild steel or cast iron. To drill a ½-in. hole in such material is a very tiresome job when done by hand and it is often impossible or too costly to take the work to a drill press. A carbon-steel, twist drill can be operated in such material, at a cutting speed of 40 ft. per min., which is about 300 r.p.m. for a ½-in. drill. In passing it is convenient to remember the following rough-and-ready rule for determining the practical speed for any size of carbon steel drill used in mild steel: R.p.m. = 150 ÷ diameter of drill. Three hundred revolutions per minute is a much higher speed than can be obtained for any appreciable time with a hand-driven, ½-in. drilling device. An estimate of the comparative speeds obtained will give a fair comparison of the length of time required to do a given job.

If we apply the above rule to find the speed for a ⅜-in. twist drill in mild steel we get $150 \div 0.375 = 400$ r.p.m. It is therefore apparent that our drilling machine should be capable of operating at various speeds to obtain the best performance over the wide range of work found by the maintenance mechanic.

Most electric drills are equipped with a motor which accomplishes automatically this adjustment of speed to drill size. It may be assumed that the working range is from two-thirds to one-half of the no-load speed. The nameplate of the machine may show the no-load speed, the speed at rated load, or both. The speed at rated amperes will be about one-half of the no-load speed. When the speed at rated load is considerably less than half the no-load speed there is ground for suspicion that the motor is overrated. A rating of 550 r.p.m. at no load and 300 r.p.m. at a load of 4.5 amp., 110 volts is about right for a ½-in. capacity machine.

Electric drills are rated according to their capacity in mild steel and are equipped with a chuck for straight-shank drills or a socket for taper shank drills in accordance with these ratings. The usual practice is to equip them with chucks, for straight-shank, twist drills in ¼-in., ½-in. and ⅝-in. sizes and with Morse taper sockets for larger sizes. The No. 2 Morse taper socket takes standard, taper-shank drills up to the $\frac{29}{32}$-in. size and the No. 3 socket accommodates drills up to the 1¼-in. size.

The ½-in. size drill is the maintenance man's tool. Whether or not

a larger or a smaller size is also desirable will be apparent when we have shown the performance to be expected from this popular size. Obviously the tool will not always be used for drilling ½-in. holes in steel. When the work required is less than the rated capacity of the drill, the operating speed will automatically increase and approach the no-load speed. Since the ½-in. tool weighs from 16 to 25 lb. it is unusual to use this size for any appreciable amount of work within the capacity of the ¼-in. tool. The latter weighs 5 or 6 lb. and has a speed and form that is more suitable for small work.

Contrary to first impressions, to turn a twist drill in wood requires more power than does the same drill in steel or other metals. This is because such a bit does not clear itself readily. The remedy is to withdraw it every inch or so of depth so as to clear the hole. It is a very good ½-in. tool which cannot be stalled in hard wood by a husky man. This is a simple test of power in an electric drill.

When holes are to be drilled in wood, it pays to have proper bits. The ordinary wood bit with the lead screw is not suitable unless the threads are ground off leaving a point for centering only. The machine-type wood bit is suitable and can be obtained in sizes up to 1¼ in. with the ½-in. shank. A good ½-in. tool will handle this bit in any dry, seasoned wood. With proper bits, holes up to 2 in. in diameter can be drilled in soft woods. For this purpose we may classify woods as follows:

"Soft" woods: poplar, spruce, white pine, cedar, white wood, mahogany.

Working Capacity of ½-in. Electric Drill

Material	Type of Drill to Use	Maximum Diam. Hole, In.
Hard Steel and Iron	High Speed Twist Drill	⅜
Mild Steel, Cast Iron, Brass, etc.	Carbon Steel Twist Drill	½
Any Seasoned Wood	Twist Drill	½
Seasoned Soft Wood	Wood Bit without Lead Screw	2
Seasoned Hard Wood	Machine Type Wood Bit	1¼

"Hard" woods: ash, maple, oak, southern pipe, birch, chestnut, hemlock, hickory, walnut.

Getting the necessary feed pressure when drilling metal is sometimes tiresome unless a feed screw or equivalent device is applicable. Very few operators have appreciated, until lately, the full value of the light stands available for use with the electric drill. Fig. 2 shows a ½-in. tool in such a stand, which is obtainable for an additional investment of less than half the cost of the drill itself. This device is so light that it may be moved about and used as a means of obtaining feed pressure. Fig. 1 shows how some mechanics use it on a Revolvator or electric tiering truck for drilling ceiling holes for motor mountings, automatic sprinkler systems, overhead track installations, and the like.

Although an electric drill does not make a thoroughly practical grinder or scratch brush it may be used for numerous odd jobs of this nature, as suggested by Fig. 3, in which case the drill is held firmly in a vise.

The table at the top of this page shows the maximum diameter of hole that a good, ½-in. electric drill will cut in different materials when used with the proper type of drill, which is also indicated in each case.

Precautions in the Use of Portable Ladders

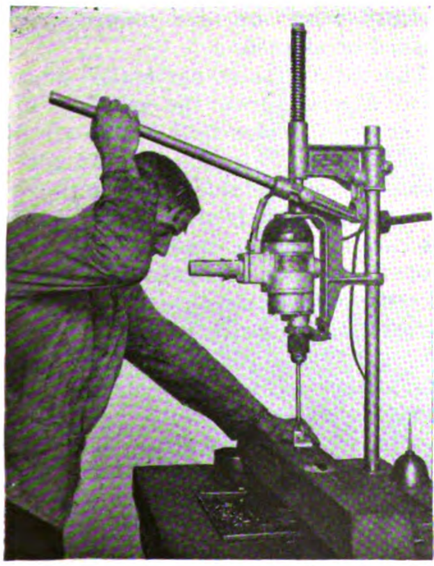
SAFE ladders, whether permanent or portable, are a necessity, as is pointed out in a report by the National Electric Light Association. The report further states that slipping of ladders on smooth or oily floors can be largely prevented by the use of cork feet or other adequate ladder shoes. In some cases the ladder can be made secure by ropes. Too much dependence, however, should not be placed on these devices, and when necessary to use a longer ladder or where there is a special hazard, a man should be detailed to guard and hold the ladder as long as another man is on it. Sufficient help should be provided to handle long, heavy ladders.

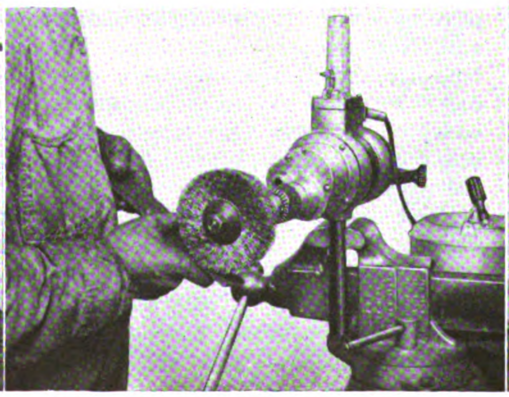
Stepladders should be of substantial construction and kept in first-class condition. Permanent ladders should be solidly anchored. Extra-long, permanent ladders should have a protecting cage built around them.

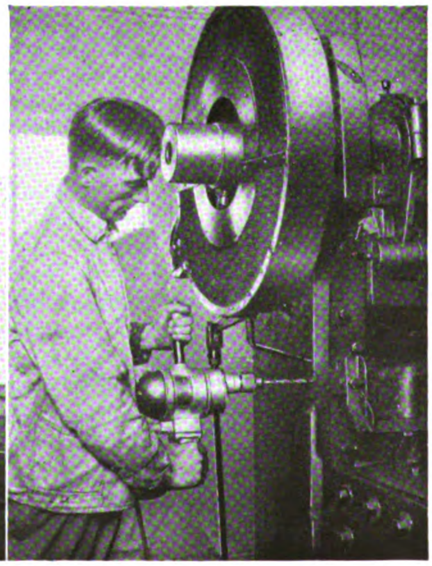
The practice of carrying tools and material up and down ladders has caused a number of serious accidents. A light handline attached to each permanent ladder should be used to hoist material that cannot be carried in the pockets without danger of falling out. Both hands must be free for climbing at all times.

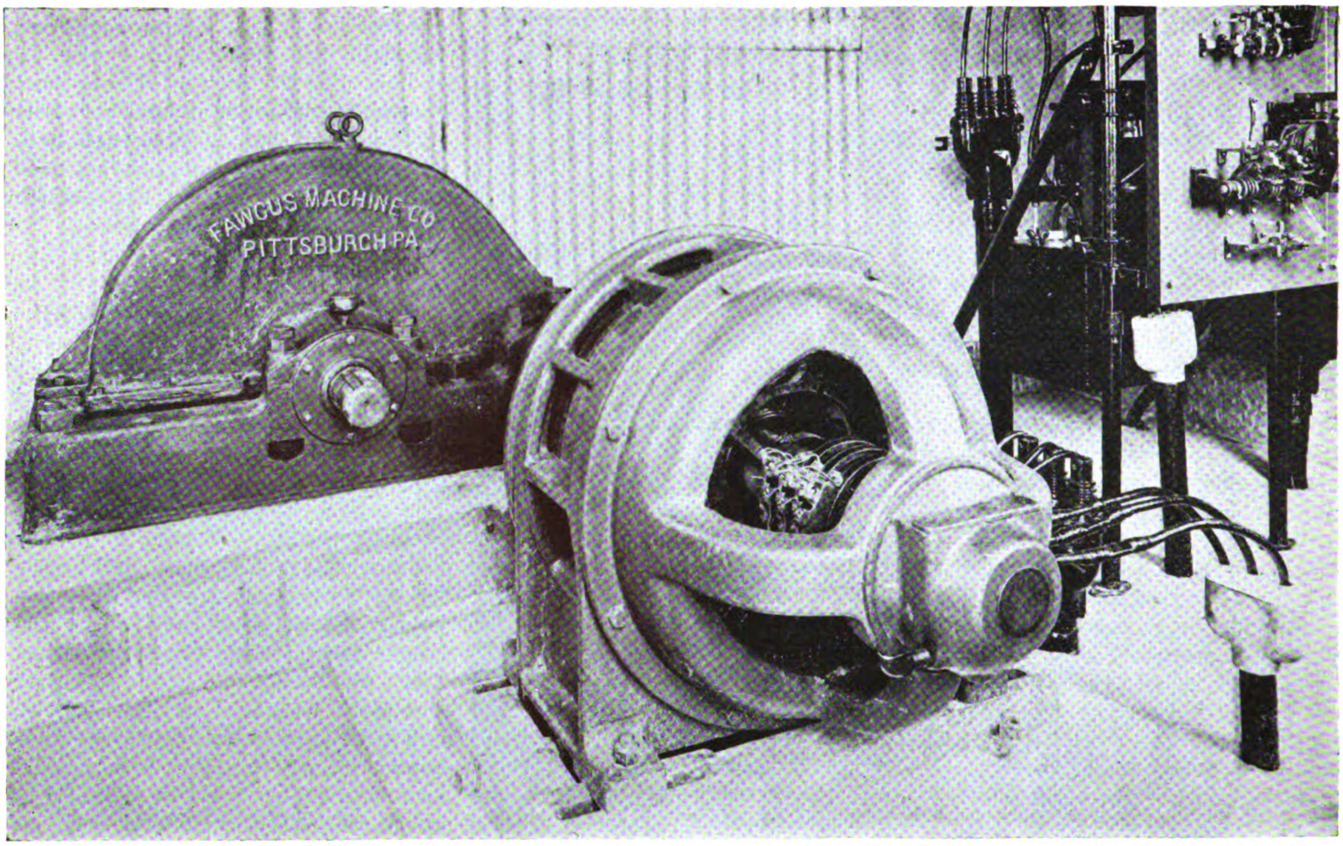
Figs. 2, 3 and 4—Here are some ways of increasing the usefulness of your electric drill.

Fig. 2 shows a portable stand that will greatly increase the convenience and speed of drilling. For light work, a grindstone or buffer may be mounted on the drill, as shown in Fig. 3. When working around machines, such as shown in Fig. 4, an electric drill will save much time and labor.









In this instance a mine fan 21 ft. in diameter is driven at 68 r.p.m. through a herringbone, roller-bearing, reduction unit.

Application of

Gears and Speed Reducers on Motor Drives

By GORDON FOX
Electrical Engineer,
Freyn Engineering Company,
Chicago, Ill.

PROBLEMS incidental to the proper connection of a motor to its load should receive as careful attention as the selection of the motor. Previous articles in INDUSTRIAL ENGINEER have covered the use of flexible couplings and belts for connecting the motor to its driven machine or load. This article will take up the considerations involved in connection with the use of gears and speed reducer or speed transformer units on motor drives.

In this discussion the term "gear drives" refers to geared connections, such as the back-geared motor or the pinion drive on the motor shaft driving a gear on the load or other gear connection between the motor and its driven machine or load, but does not include speed reducers, which are discussed under later headings.

Gear drives permit compact arrangement, are positive and afford a definite speed reduction. They are particularly adapted for low-speed work for which other drives may be unsuited. Gear drives have fair efficiencies, which range from 90 to 98 per cent for each gear reduction, depending upon type, speed, lubrication and other operating conditions. For long life and efficient operation, gear drives require good initial alignment, which must be well maintained. They also require lubrication and generally inclosure for safety, for protection against dust and to facilitate lubrication.

On the other hand, gears transmit to the motor most of the shocks to which they are subjected. Gears also transmit vibration and are usually more or less noisy, especially with high speed and metal-to-metal contact. These objectionable features are increased when the gear teeth become worn or are improperly meshed or aligned.

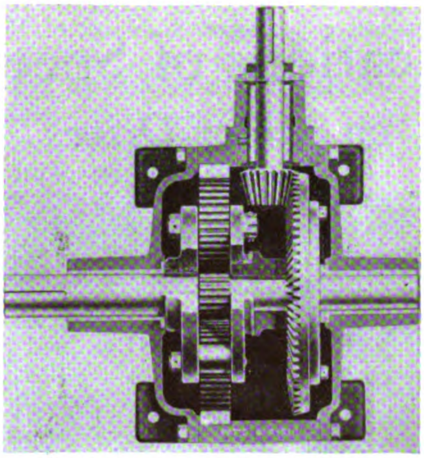
The ratio of any particular gear drive depends upon the relation of motor speed under load and desired machine speed. In the case of constant- or adjustable-speed motors this ratio is easily determined. In the case of varying-speed motors the proper ratio is not always so readily determined, because the motor speed varies with the load. For drives that are started and stopped frequently, the factors of machine and motor inertia may materially affect the selection of the proper gear ratio.

The allowable ratio for a single reduction of spur gears is limited by the allowable diameter and surface

speed of the gear and by the minimum number of pinion teeth. For small motors a 10 : 1 ratio is allowable; for motors of moderate size, 8 : 1 is about the maximum ratio permissible. The motor pinion should have at least fifteen teeth, if possible, because the teeth of smaller pinions are weakened by the necessary undercutting. In determining a ratio of gearing it is well to avoid the maximum possible ratio, as this leaves no margin for future change, should such be found advisable. It is better to use an intermediate ratio, but to provide clearances that will permit a change of the gear ratio in either direction, if desired later. In calculating a gear reduction the gear should, if possible, have a prime number of teeth in order that the shocks due to a repeated cycle of operation may be distributed; the use of an odd tooth prevents the same teeth from meshing so often.

When motors have double-extended shafts, placing the pinion on the commutator end should be avoided, if possible, because the shocks and vibration are more serious and the bearing wear is likely to be more rapid. Outboard bearings should be used for all geared motors of 100 hp. and larger and, in many cases, for smaller motors. Also, outboard bearings should be used for general-purpose motors of 50 hp. and above when subjected to reversing duty or severe fluctuating loads.

The motor pinion should be located preferably on the same horizontal level and to one side of the driven gear. Bearing wear on slight errors in elevation then have little effect. It is not good practice to locate the motor pinion directly below the driven gear. Bearing wear is then likely to throw excess weight on the motor bearings. It is also difficult to remove armatures so located. If



Cutaway view of a right-angle planetary reducer.

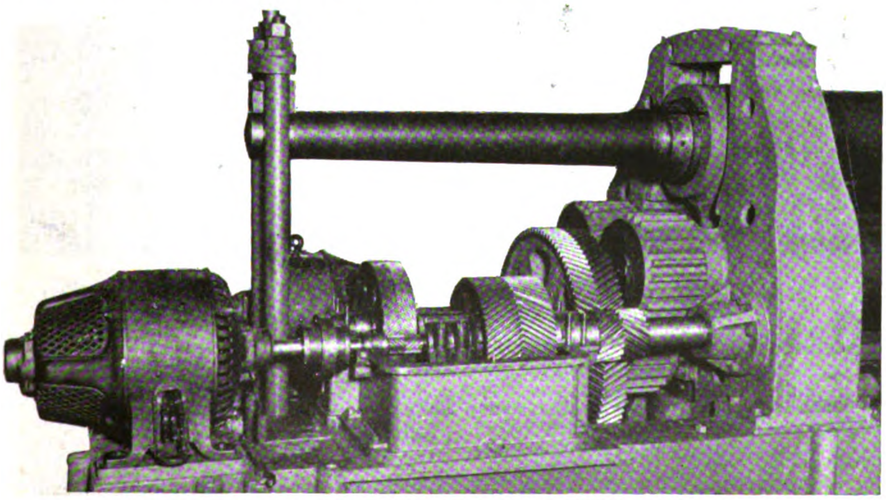
The high-speed drive is connected to the small bevel gear and the low-speed shaft is at the left. This is a Ganschow single-reduction planetary unit. In the latest model a roller bearing is used on the high-speed shaft.

the arrangement is such that motor elevation affects the meshing of the gearing (the same is true in connection with flexible couplings on drives), it is advisable to have the motor support a trifle low and to build up with shims under the motor feet. This arrangement also permits adjustment to care for slight differences between individual motors.

Gears are usually of cast iron or cast steel with cut teeth, whereas pinions may be of steel, brass, fiber, rawhide or cloth. The two latter types have end plates of brass. Steel pinions have excellent life and are not affected by temperature or moisture, but are noisy and cut quickly unless well lubricated. Cast-steel gears are about 75 to 100 per cent stronger than those of cast iron.

Here the input speed of 900 r.p.m. is reduced to 3⅞ r.p.m.

This Farrel herringbone reduction unit is used to drive a plate-bending machine.



They should be used for important work, where shock or overload may be expected or where the face of a cast-iron gear would exceed 4½ in. The cost of cast-steel gears is about 60 to 100 per cent more than for cast-iron gears of the same dimensions. This difference is greater on large gears than on small ones.

The pinion is subject to the more rapid wear, due to its smaller diameter; therefore it is important to have a pinion of good wearing qualities as well as of sufficient strength. Heavy-duty steel pinions are usually forged of 0.30 to 0.40 per cent carbon steel and are frequently heat-treated to increase their strength and durability. This is particularly true in connection with crane and other mill motors.

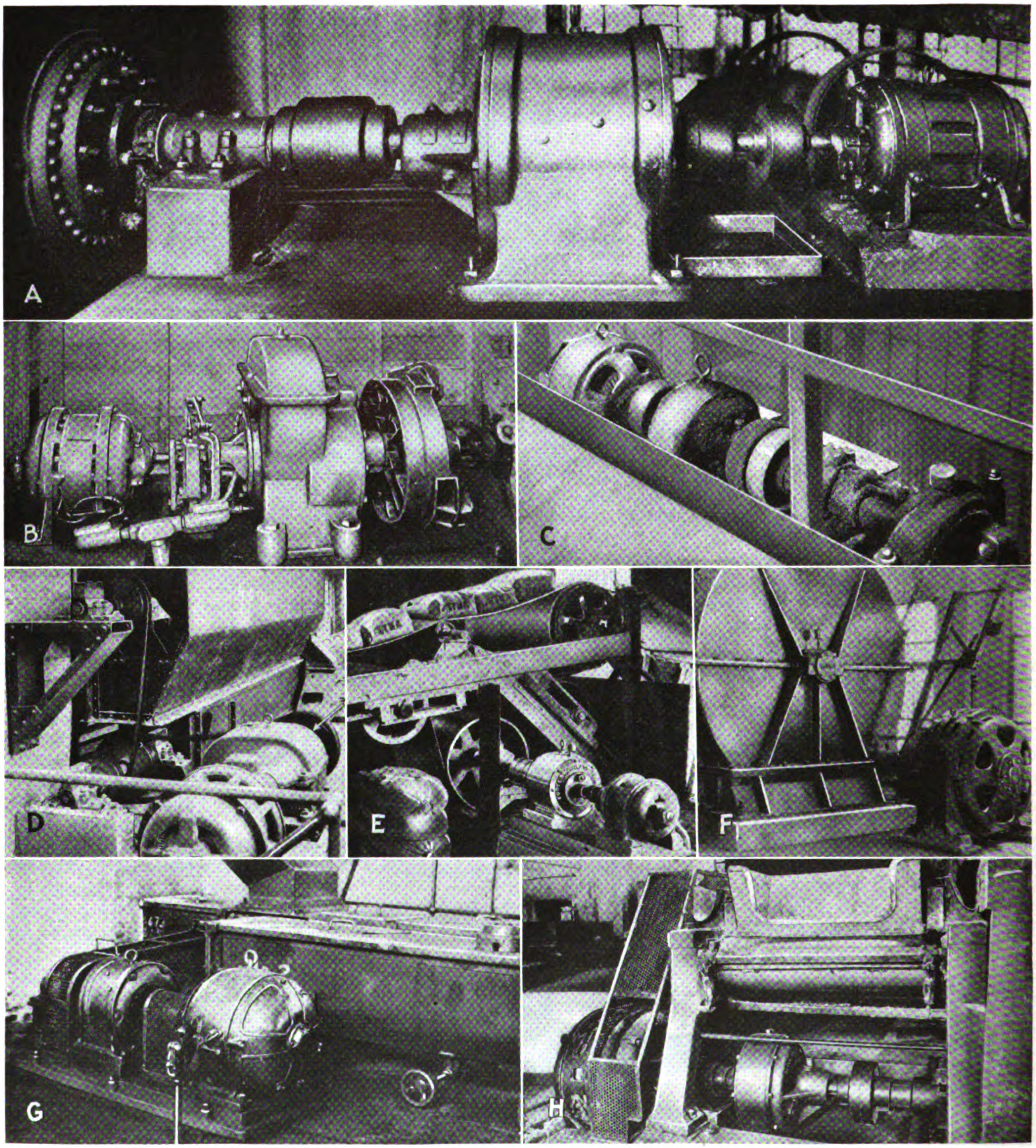
Iron and steel gears ordinarily become noisy at about 800 f.p.m. linear speed, but may not be disagreeably noisy below 1,200 f.p.m. or even higher. Where it is desired to employ high surface speeds without noise, brass, fiber, rawhide or cloth pinions may be used. Brass pinions, although somewhat quieter, have shorter life than those of steel; they are particularly adapted to extreme conditions of heat and moisture, which prohibit the use of a non-metallic pinion where noise is objectionable.

Fiber pinions are quiet and can be used under any ordinary conditions and many unusual conditions, except extremes of heat and moisture. Rawhide pinions are satisfactory unless subjected to extremes of heat or moisture, excessive load fluctuations, or frequent starting, stopping or reversing. The American Association of Gear Manufacturers recently adopted the recommendation that all non-metallic gears or pinions be estimated on a basis of 75 per cent of the rating of cast-iron gears of corresponding dimensions.

The surface speed of a rawhide pinion is limited more by rapid wear than by noise. A speed of about 2,000 f.p.m. is a fair average limit, but 2,500 to 3,000 f.p.m. may be used under favorable circumstances of attendance and lubrication, in the absence of moisture and for intermittent service where the life of the pinion is not important. Cloth pinions are quiet, not easily affected by ordinary heat or moisture, are quite elastic and give good service when subjected to strains and shocks. The allowable surface speeds correspond to the values for rawhide.

Where quiet operation is desired,

Eight Applications of Speed Reducers
on Motor Drives



A—Here a 15-hp. 1,160-r.p.m. motor drives paper mill equipment at a reduction of 192 to 1 through a D. O. James planetary reducer.

B—A car haul is driven by this Hill-Clutch Type C 46:1 speed transformer through a friction clutch and solenoid brake control.

C—Because reducers are totally enclosed they can be operated satisfactorily in very dusty surroundings, such as shown here. This is a Ganschow planetary reducer.

D—This screen and screw conveyor in the packing plant of the Peerless Portland Cement Co., Detroit, Mich., is driven at the required speed by a Palmer-Bee mill-type speed reducer.

E—Here a conveyor for loading cars in the Aetna Portland Cement Plant, Bay City, Mich., is driven by a Foote IXL non-planetary speed reducer.

F—One of 11 elevator drives requiring 175 hp. in a single reduction from 485 to 27½ r.p.m. through Fawcus herringbone gears. The motor is connected to the pinion by a Webster special steel-plate clutch. Power is transmitted from the gear shaft to the elevator headshaft through a Fawcus semi-flexible coupling.

G—An example of a compact drive arrangement of a D. O. James planetary speed reducer driving a screw conveyor through a chain.

H—This is a Philadelphia 10½:1-ratio spur gear speed reduction unit which is connected to a 50-hp., 1,200-r.p.m. motor that drives a two-roll calender mixing machine in a linoleum plant.

Table I—Safe Working Stresses for Gear Materials

These values are to be used in connection with the computation of a gear or pinion and must be reduced according to the strength factors in Table II.

	Ordinary Grade	High Grade
Non-metallic	6,000	8,000
Cast-iron	6,000	8,000
Phosphor bronze	9,000	12,000
Cast steel	12,000	15,000
Steel	15,000	20,000-35,000

Table II—Strength Factors for Gears

Pitch Line Speed, Ft. Per Min.	Strength Factor
100	0.857
200	0.750
300	0.666
450	0.571
600	0.500
900	0.400
1,200	0.333
1,800	0.250
2,400	0.200

rigid and massive supports and close-fitting bearings, both on motor and driven machine, are conducive to a noiseless drive. Where the mounting or foundation of the motor and its machine are not substantial enough, the tooth pressure tends to force the gears and machines apart, which adds to tooth wear and noisy operation. The pinion should always be placed as close as possible to the motor bearing. Long overhung pinions not only increase the pressure on the bearing but also increase the likelihood of a sprung or bent shaft in case of a serious shock load.

Gears must be kept well oiled, and at high speeds some method must be used, the effectiveness of which will not be destroyed by centrifugal force, to maintain an oil film at the point of tooth contact. Rawhide gears should not be oiled, but should be lubricated with talcum and graphite or graphite and lard oil. Gears should always be guarded, not only for safety and for protection but also to prevent throwing of the lubricant. Inspection openings should be provided in the gear guards at the point of meshing.

The selection of gears is a rather comprehensive subject and can be treated only briefly in this limited space. However, a method of determining sizes of spur gearing, which is based on the Lewis formula, will be outlined. Usually the horsepower, speeds and approximate distance between centers are given. With the gear ratio and center-line distance known approximately, a pinion diameter can be selected for trial. It is first necessary to calculate the tangential pressure at the pitch line from the formula:

$$T = (Hp. \times 126{,}000) \div (D \times \text{r.p.m.})$$

where T = Tangential pressure at pitch line in pounds

$Hp.$ = Horsepower to be transmitted, including allowance for starting and overloads

D = Pinion diameter in inches

$r.p.m.$ = Pinion speed.

The approximate pinion diameter being known, the linear speed at the pitch line can be readily calculated. From Table I select a unit stress for the material to be used for the gear or pinion, using whichever is weaker if both are not of the same material. Correct this unit stress by multiplying by the strength factor given in Table II for the linear speed determined. The resultant unit stress may now be used for determining the gearing.

Let T = tangential pressure at pitch line in pounds

S = unit stress allowable

P = pitch diameter in inches

Y = correction factor for tooth outline from Table III

V = linear velocity at pitch line in feet per minute.

Assume a value for P and solve the following formula to determine a value of F.

$$F = TP \div SY$$

Also solve the following formula to determine a value of F:

$$F = [(0.15\ \sqrt{V}) + 9] \div P$$

If the two values of F thus obtained are approximately the same, the assumed value of P is satisfactory. Otherwise a new value of P must be assumed and the process repeated.

When satisfactory values of P and F are determined as above, the number of teeth in the resulting pinion and gear and their general proportions can be checked and the nearest commercial size selected.

Drive Considerations When Using Speed Reducers

Self-contained spur- and worm-gear speed reduction units are gaining popularity, particularly where the reduction ratio is high. These units afford a number of advantages in comparison with a train of gears. Ordinarily, the reduction unit occupies less space than a gear train for a given reduction of speed, and also permits of large ratios in a unit assembly. Their use often makes it possible to use a higher-speed motor.

Table III—Outline Factor "Y" for Gear Calculations

No. of Teeth	Outline Factor 14½ Deg. Involute and Cycloidal	20 Deg. Involute
12	0.210	0.245
13	0.220	0.261
14	0.226	0.276
15	0.236	0.289
16	0.242	0.295
17	0.251	0.302
18	0.261	0.308
19	0.273	0.314
20	0.283	0.320
23	0.295	0.333
25	0.305	0.339
27	0.314	0.349
30	0.320	0.358
38	0.336	0.383
50	0.352	0.408
75	0.364	0.434
100	0.371	0.446
300	0.383	0.471
Rack	0.390	0.484

Because the reduction units are inclosed, they are easily lubricated and are protected so that they can be used in dirty and damp places. Also, because of their inclosure, they are safe. In most designs of spur-gear reducers a straight-line drive is afforded, which is advantageous. The units transmit torque directly through couplings and do not impose flexural loads on the bearings of the motor or the driven machine.

Briefly, speed reducers, or speed transformers, as they are frequently called, consist of a cast-iron or cast-steel case, fitted with especially arranged spur-gear trains or with a worm and worm gear. The discussion of these will be treated separately here.

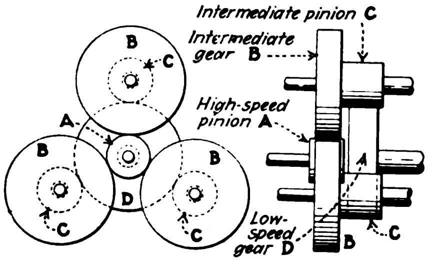
The several types of spur-gear speed reducers may be classified as: (1) plain spur: (2) planetary; (3) non-planetary; and (4) parallel shaft, such as mill type, helical and herringbone. The construction and operation of the plain spur, planetary and non-planetary reducers are illustrated by sketches and their operation is described in the caption accompanying each and so will not be repeated here. In each case high reductions are obtained by means of two-, three- or multiple-stage reductions, which consist of two or more single-stage units built together in the same case.

The first three of these spur-gear types of reducers have several features in common—namely, (a)

straight line reduction; (b) two reductions in a single stage; (c) the use of three intermediary gears driven by the high-speed pinion; and (d) these gears divide and distribute the torque on both the high-speed pinion and the low-speed gear.

Each of these types also has some advantages due to the design. However, a point often overlooked is the effect of the quality and accuracy of manufacture, which affects the efficiency of transmission, life of the unit and satisfactory operation. In some units ball or roller bearings are used on some of the bearings.

Although spur-gear reduction units are a straight-line drive, modifications are obtainable to give a right-angle drive. This consists of a bevel gear on the incoming shaft, which enters on the side, that meshes with its mating bevel on what would ordinarily be the incoming shaft. A cross-section of a right-angle, single-

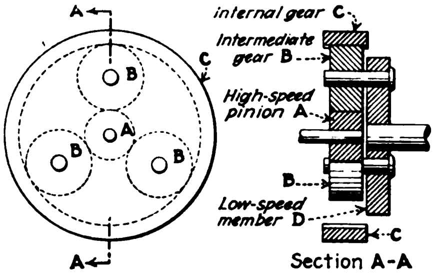


The plain spur-gear reducer consists of a series of spur gears, each revolving about its own center.

The high-speed pinion meshes with three idler gears, contacting on the pinion at points 120-deg. apart. On common shafts with these three gears are three pinions meshing at points 120 deg. apart with a larger gear which is keyed to the low-speed shaft. High-speed pinion *A* meshes with the three gears *B*; pinions *C* mesh with gear *D*. Essentially, there are five elements in this single-stage reducer: namely, the high-speed shaft and pinion, three counter-shafts each carrying a large gear and smaller pinion, and the slow-speed gear with its shaft. Although there are two reductions, this is known as a single reducer. The double reducer has two stages in series, with a partition between them.

reduction planetary unit is shown in one of the accompanying illustrations. The bevel gear, however, gives some additional reduction.

Right-angle, spur-gear drives may be arranged for right- or left-hand connection or for vertical drive with the low-speed shaft extending either up or down. The vertical units are widely used on agitator drives; this permits placing the motor at one side out of the fumes, heat or moisture. Also, right-angle drives are used where space will not permit a straight-line connection, such as on a machine located alongside an aisle or wall.

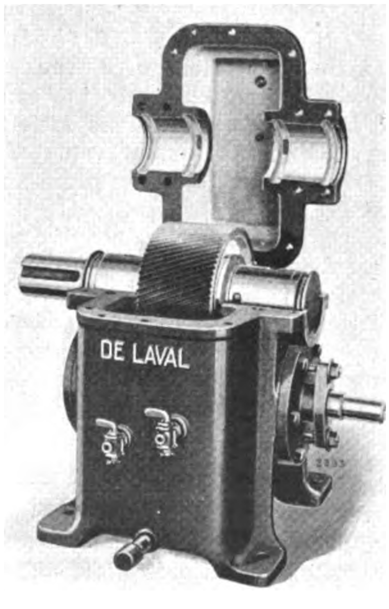


Cross-section view of a planetary gear reducer.

The planetary reducer employs a stationary internal gear in addition to spur gears. The high-speed pinion *A* meshes with the three intermediate gears *B* which are journaled on shafts that extend from plate *D* which is integral with or keyed to the low-speed shaft. The three intermediate gears *B* also mesh with a stationary internal gear *C*. This arrangement causes the entire unit consisting of the three intermediate gears *B*, the plate *D*, and the low-speed shaft to rotate. This description refers to a single reducer. For high ratios two or more such stages are combined in series.

The parallel-shaft type of gear reducer is essentially a condensed gear train that is inclosed and assembled as a unit. Sets of this type are shown in accompanying illustrations. This type of reducer may or may not be a straight-line drive, depending upon the specific design. Some manufacturers specialize on spur gears and others on herringbone gears for these units. Such units have the reduction field practically to themselves in the transmission of large amounts of power.

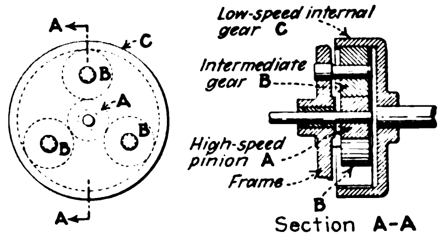
The amount of reduction obtainable with the various units varies somewhat with the different types and designs of the different manufacturers. Roughly, the variation is



A De Laval helical gear speed reducer with the cover removed to show the gear and bearings.

from about 3 : 1 or 4 : 1 in the single-stage units up to about 200 : 1 in the multiple-stage units of the plain spur, planetary and non-planetary types. Parallel shaft reducers begin at decimal ratios slightly higher than 1 : 1 to several hundred to one in the multiple units. Sometimes it is feasible to equip a reducer for a given gear ratio adapted to present requirements with provision to change to a new ratio at a later date by changing the gears.

All gear-reduction sets have a given torque capacity, the horsepower rating depending upon the speed and the ratio of reduction. The higher the ratio of reduction the lower the horsepower rating. These sets are available for motors up to about 200 hp., the higher horsepower being confined to the smaller ratios. The sets are available for motor speeds up to 1,800 r.p.m. in the lower horsepowers and up to 900 to 1,200 r.p.m. in the higher horsepowers.

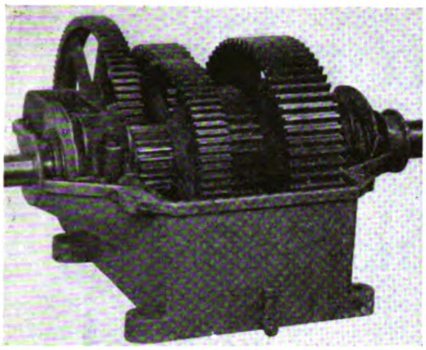


The gear arrangement in a non-planetary type of reducer.

As in the planetary type, the small, high-speed pinion *A* makes a three-point contact with three intermediate gears *B*. These, in turn, mesh with an internal gear *C*. In the non-planetary type, however, the intermediate gears *B* are journaled in the frame and the internal gear *C* is free to move because it is integral with or keyed to the low-speed shaft. For high ratios, series combinations may be used, with partitions between each stage; the intermediate gears are journaled in these partitions.

The horsepower ratings given to the sets by the manufacturers are rather nominal and are not a definite measure of capacity. Generally, the ratings are based on favorable, uniform load conditions. For severe service where subject to shock or reversal of rotation it is well to discount the ratings 25 to 50 per cent, depending upon the severity and the continuity of service.

Ordinarily all types of these gear sets are direct coupled both to the motor and to the driven machine. The use of flexible couplings for these connections is practically always advisable. Also, a rigid foundation is always advisable, and practically all manufacturers will supply cast-iron bed plates for the motor



An example of the mill type or parallel shaft speed reducer.

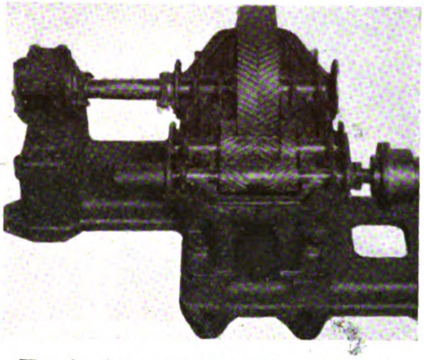
This is a Palmer-Bee mill-type unit with multiple reduction. The high-speed shaft is at the left and the slow-speed shaft at the right.

and the reducer. Where speed reducers are not direct coupled, but drive or are driven by belt or chain, outboard bearings may be needed.

The efficiency of a spur gear reducer set depends upon many details of design. Particularly well-constructed sets, including those equipped with ball or roller bearings and herringbone gears, have materially higher efficiencies than the ordinary commercial sets.

Herringbone gears are now extensively used for the larger motors and more severe service as well as for high-speed work. They offer the advantage of continuous and smooth action and largely eliminate backlash. As a result of the continuous tooth contact, which eliminates shock, and also since the teeth are stronger because of their angular position, the pitch required for any given conditions can be much finer than would be chosen for spur gears. Smaller pinions, too, may be used and therefore higher ratios can be obtained in a single reduction. It is desirable, however, to maintain sufficient pitch-line speed to restrict required tooth pressures. Gears of this type are relatively quiet.

Although herringbone gearing is sometimes used in a manner similar to spur gearing, with the pinion



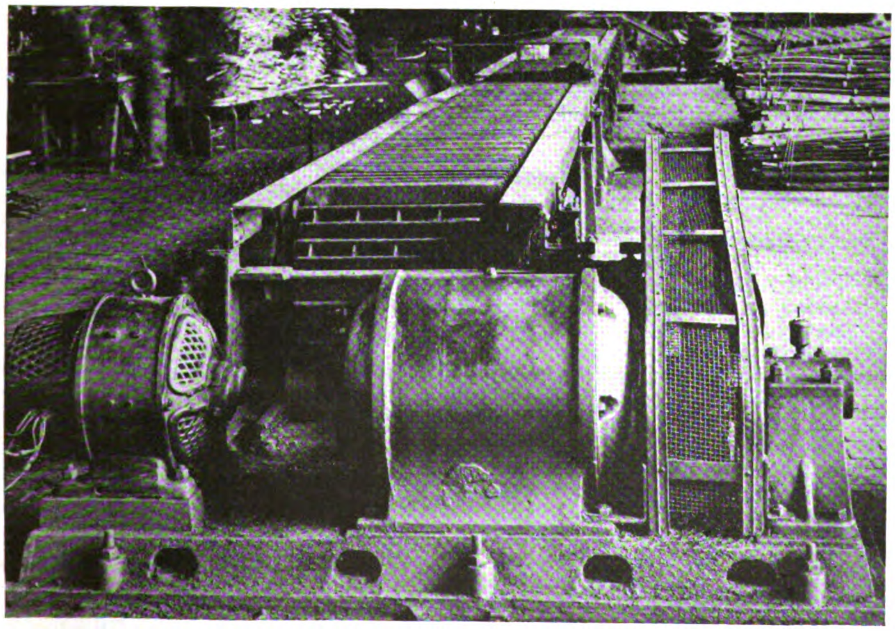
Herringbone double reduction unit with the gear cover removed.

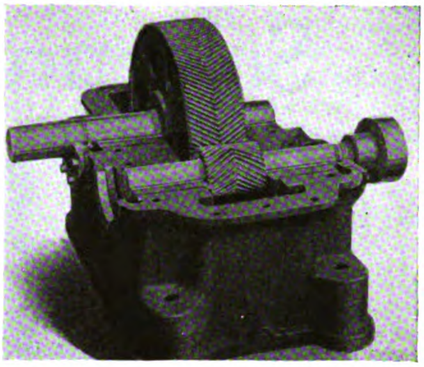
The entire unit, including the motor, is mounted on a cast-iron bed plate; the motor is connected through the flexible coupling at the right. This is a Falk reducer. An outboard bearing is provided on the low-speed shaft, for pulley, sprocket or gear connection.

mounted directly on the motor shaft, this type of gear is used more commonly in a gear reduction set. When the pinion is mounted on the motor shaft, particular care must be exercised to align the gear with the rotor

This coil conveyor is driven by a chain from the low-speed shaft of a spur-gear speed reducer.

Here a 5-hp., 500-1,500-r.p.m. variable-speed motor drives the Jones reducer that has a reduction ratio of 125.4:1. Because of the overhung load on the chain drive, an outboard bearing is used.





This is a Farrel single-reduction, Sykes herringbone speed reducer.

in its magnetic central (center) position. Even with this precaution it is difficult to obtain and maintain the accurate alignment desirable for best operation of this type of gearing as a motor pinion.

Herringbone gear sets are commonly of the parallel-shaft type. Typical units are shown in accompanying illustrations. Ratios up to about 18 : 1 may be obtained in a single reduction; standard double-reduction sets afford ratios up to about 50 : 1 and ratios up to 250 : 1 are obtainable in multiple units. Usually the gearing is incased and operated in an oil bath. The quality and the level of the oil are important factors. In the larger sets, oil-circulating systems are often used.

These units have high efficiencies; the single-reduction units have efficiencies up to 98 per cent and double reduction units have efficiencies up to 95 per cent.

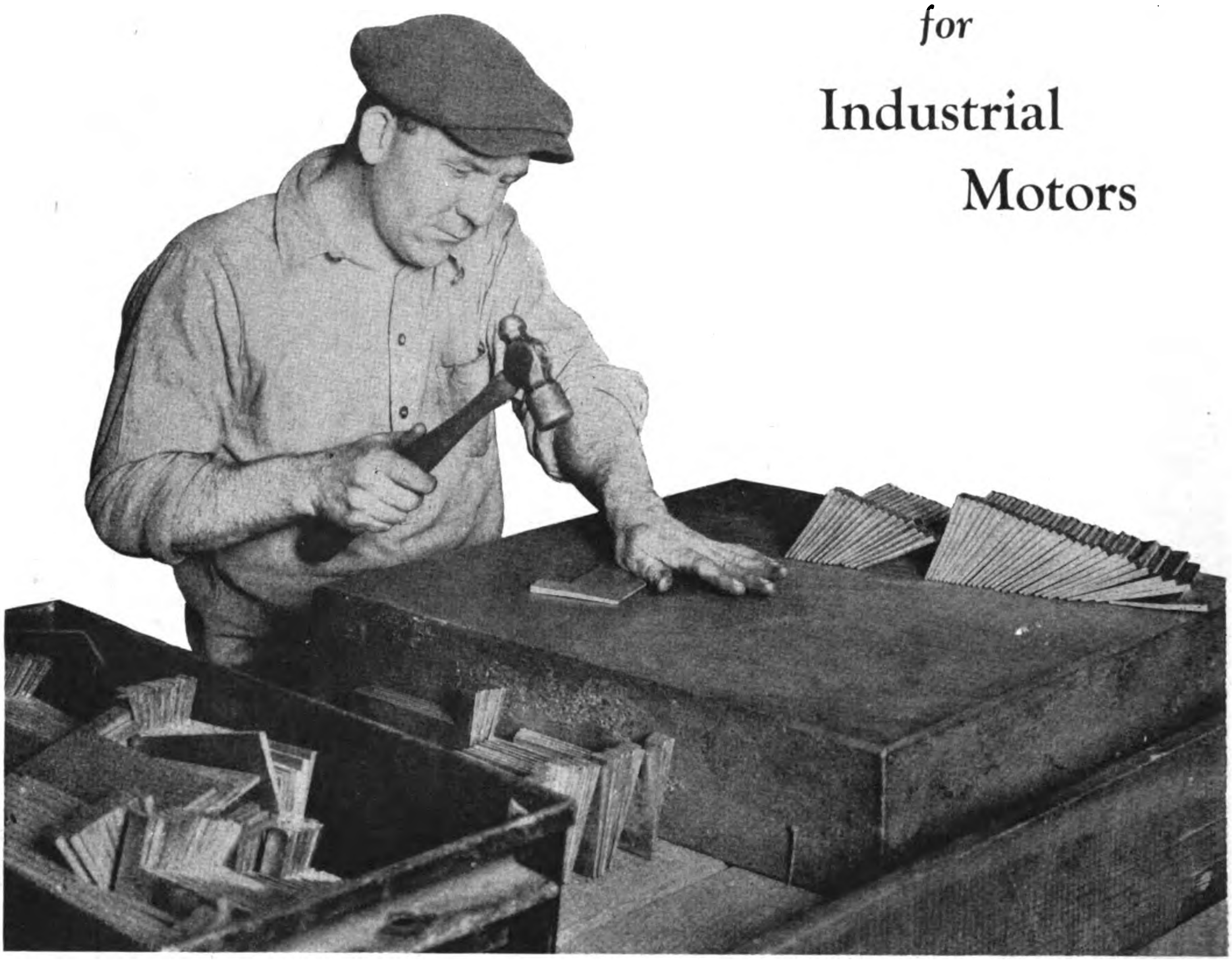
The use of a flexible coupling between the motor and a herringbone gear set is advised, particularly to relieve the pinion of any end thrust.

Helical gear reducers may be used for low ratios of reduction, approximately up to 5 : 1. This gear has many of the advantages of the herringbone gear and is materially cheaper. It causes a definite end thrust, however, which is a limitation.

Another article to appear in an early issue will take up worm-reduction units and variable-speed drives.

EDITORS' NOTE: Acknowledgment is made to the following companies for illustrations and information used in the preparation of this article: Albaugh-Dover Mfg. Co., Chicago, Ill.; DeLaval Steam Turbine Co., Trenton, N. J.; The Falk Corp., Milwaukee, Wis.; Fawcus Machine Co., Pittsburgh, Pa.; Foote Bros. Gear & Machine Co., Chicago, Ill.; Wm. Ganschow Co., Chicago, Ill.; The Hill Clutch Machine & Foundry Co., Cleveland, Ohio; D. O. James Mfg. Co., Chicago, Ill.; Palmer-Bee Co., Detroit, Mich.; and Philadelphia Gear Works, Philadelphia, Pa.

Selecting Commutator Bars for Industrial Motors



Straightening the copper bars before assembling them in the commutator.

By JESSE M. ZIMMERMAN
Renewal Parts Engineer,
Westinghouse Electric & Mfg. Company,
Pittsburgh, Pa.

A COMMON trouble experienced with commutator bars is what is known as copper sickness. This trouble can be avoided as has been brought out by Mr. Piling in an article published in *Electric Journal* for August, 1920. Commercial copper has a small percentage of oxygen in the form of copper oxide. Without oxygen, copper has poor mechanical characteristics. It should not be heated in a gas flame if it is at all possible to heat it in any other manner, and never in a flame which is rich in free hydrogen because the hydrogen unites with the oxygen in the copper, producing water in the form of steam. Hydrogen readily enters hot copper, but the steam produced cannot escape. This causes the copper to be not only weakened by the loss of its oxygen, but also results in the expansion of the copper by the high-pressure steam. This makes the copper spongy and still weaker. The effect is greater near the surface which is directly exposed to the flame.

Workmen can avoid "sick copper" by not heating commutators with a flame played directly on the copper. If it is absolutely necessary to heat a commutator by applying the flame directly on the copper, it should be out of the inner cone of the blue flame. If a gas and air torch or furnace is used for heating copper, an excessive amount of air should always be used, as too little air will produce an excess of free hydrogen. Smoke from such a torch is always an indication of too little air. The mixer should be adjusted to give a little more air than is necessary to prevent any trace of smoke.

THIS is the second article of a series on the selection of the materials and the methods used in building and repairing commutators. The first article, which appeared in the December, 1926, issue, dealt with the selection of mica. In the present article the selection and use of copper for commutator bars are considered. The third article, which will appear in an early issue, will discuss the assembly of commutators.

The electric conductivities of metals and their alloys bear a fairly close relation to their heat conductivities. Through extensive tests, it has been found that very little impurity in copper will reduce the

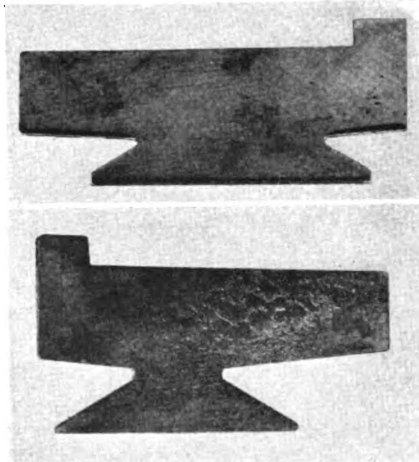
conductivity to possibly one-third. Most of the alloys of copper have very low heat conducting properties compared with those of pure copper. Silver has a lower heat conductivity than copper alloy. Accordingly, a commutator made of silver should give the best commutation. It does, but is not available as it is too expensive for this use.

Anything which tends to increase the heat-conducting properties of a commutator will tend to decrease the burning action. This has been clearly demonstrated in an elaborate test of carbon brushes on a collector ring, where the question of commutation could not disturb the conclusion. Such tests were made on cast iron, wrought iron, bronze, various alloys including cast copper, and pure copper. With high current densities, the burning and blistering action appears to be dependent upon the ability of the metal to conduct the heat from the contact surface. The fusion of the metal on good heat-conducting materials will be so small that the polishing action of the brush will keep the surface in a smooth, glossy condition. Some of the older types of alternating-current motors use collector rings made from cast iron and steel because of the low current density.

In the course of the development of commutating machinery, silver, pure copper, both hard and soft, various copper alloys and brasses, cast copper of various purities, aluminum, wrought iron and even cast iron have been tried. Experience has shown that all of them can be used in commutators if one is willing to pay for the high price of maintenance and unsatisfactory operating characteristics plus a higher first cost, because the use of any other metal than pure copper or silver will mean a larger commutator. This in turn will mean an increase in size of the machine.

An experimental commutator was made with iron bars. The commutator soon developed high mica, and the commutating surface became blackened and blistered. Sparking gradually increased until commutation reached a state where it was impossible to operate the motor. High mica was not caused by the metal wearing faster than the mica. It was caused by the contact surfaces burning away, leaving high mica.

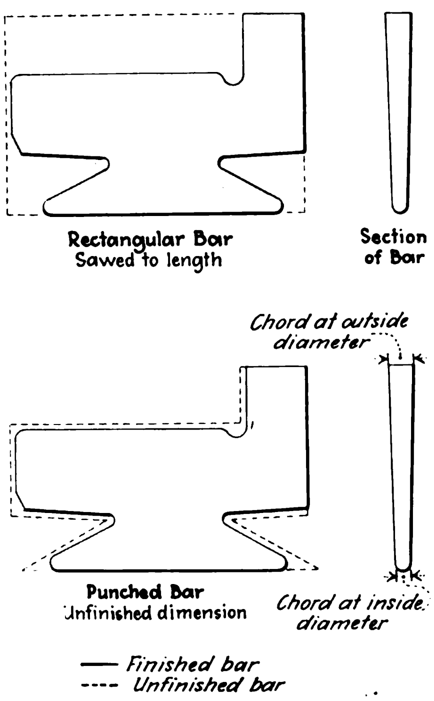
Aluminum was also tried. It worked better than iron, in that burning, blackening and high mica did not appear so quickly. However, like iron, it did not take a polish and soon had a dull appearance, which gradually turned black and burned badly. The high resistance of the aluminum oxide which formed on the surface due to sparking, and the high mica caused by the burning of the contact surface, increased the contact resistance.



These illustrations show the difference between cast copper and hard-drawn copper commutator bars.

The bottom illustration shows a cast copper bar. Note the round edges and sand holes left in the bar.

Bronze, brass, cast copper, and copper alloy were tried for commutor work. While they gave better results than aluminum or iron, the commutator would develop high mica more quickly than those built of hard-drawn copper made from pure copper ingot metal. This burning action is a function of the contact resistance, current density, and the non-burning and non-blistering qualities of the metal used in the commutator.



Spare commutator bars as used in production, and as supplied for repair purposes.

The use of copper alloy, which costs almost as much as hard-drawn copper, does not warrant the increased cost of maintenance and interruption of service. Furthermore, if a commutator having copper alloy bars whose conductivity ranges from 50 to 60 per cent is substituted for a commutator made of pure copper and which is working at its maximum temperature, it certainly will be overheated.

Copper can be cast in sand molds, but difficulty is encountered in the formation of blowholes, which are caused by the pocketing of the gas during cooling. An example of this is shown at the top of this page. It is also very difficult to control the conductivity of cast copper. Some of the copper bars may have a high conductivity, while other bars may have a very low conductivity. For this reason many manufacturers will not sell cast copper material under a contract that it will have more than 75 per cent conductivity.

In the Question and Answer department of the June, 1926, issue of INDUSTRIAL ENGINEER the merits of cast copper versus hard-drawn copper were thoroughly discussed. The following brief summary of these discussions will show the operating man's viewpoint:

"Cast copper commutators are a continual source of trouble."

"Soft and hard places result in uneven wear, making it necessary to turn the commutator once every month."

"Had to clean out between bars every day or so. Only one thing can be truthfully said in favor of cast commutators—the price is cheaper than that of hard drawn copper."

"When through wear a sand hole or spongy part is exposed on the contact surface, trouble begins."

"Cast copper is of very low grade and is likely to be porous. Its wearing qualities are from 75 to 90 per cent of those of hard-drawn copper."

"Pores in cast copper fill up with carbon dust off the brushes and cause heating."

"When one considers that cast copper has 20 per cent less conductivity the heating becomes quite an item."

"It has been my experience that the operating man who pays atten-

tion to the advice of the motor manufacturer has the least trouble and expense. The motor manufacturer's organization and integrity are founded on years of experience and at a considerable cost in trying to put out the best product possible; so when the motor manufacturer advises the use of good copper for commutators, he speaks from a background of experience in manufacturing and repairing them."

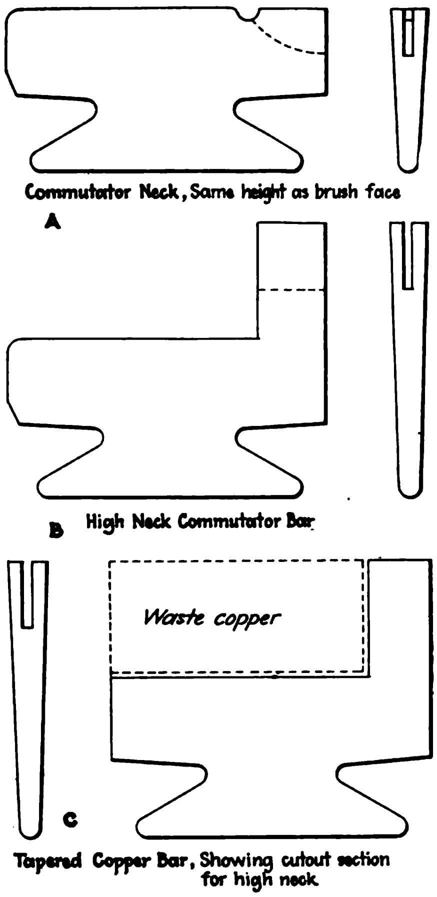
From the foregoing remarks, it is evident that copper bars to be used in renewing a commutator should be of same material and workmanship as the original copper bars. Purity is one of the important points worthy of consideration.

The copper bars should be made from pure, hard-drawn copper whose conductivity is not less than 98 per cent, 100 per cent being based on copper having a resistance of 9.59 ohms per mil-foot at 0 deg. C.

Hardness should also receive due consideration. The copper bars should be made of hard-drawn copper, having a Brinell hardness number of not less than 75. They should be able to withstand a fiber strain of 25,000 lb. per sq.in. in order to overcome the stresses due to centrifugal force of rotation and stresses caused by alternate heating and cooling of the commutator while in service. The Brinell hardness number for cast copper bars which are afterward cold pressed to size is from 50 to 55. Soft copper has a Brinell hardness number of 38 to 40. From this it can be seen that the hard-drawing process will produce better commutator copper than the other method.

The die, through which the copper is drawn, is called a section. The opening in the die conforms with the cross-section of the bar, as shown in the drawing on page 169. During the drawing process, samples are taken for chemical analysis, hardness test and gaging of the section. Gaging is a frequent operation to see that the size of the bar remains uniform. In the manufacture of high-grade commutators there are certain specifications which the bars must meet. Some of these specifications prescribe certain limitations, which are listed as follows:

(1) The copper bar must not vary from the specified section at either



These are types of solid-neck commutator bars.

drawn edge by more than plus or minus .001 in. The algebraic difference at the two drawn edges must not exceed 1 mil. If this variation is not adhered to, the distance from any bar to the corresponding bar under the next pole may vary more than plus or minus 1/32 in. If this variation is larger or smaller, sparking will be prevalent at these spots. This is equivalent to increasing or decreasing the width of the commutating zone while the brush setting remains constant. Consequently, when a wider or narrower commutating zone passes under the brushes, they must short-circuit bars connected to coils whose potential is not zero. Therefore, sparking will be prevalent at these points.

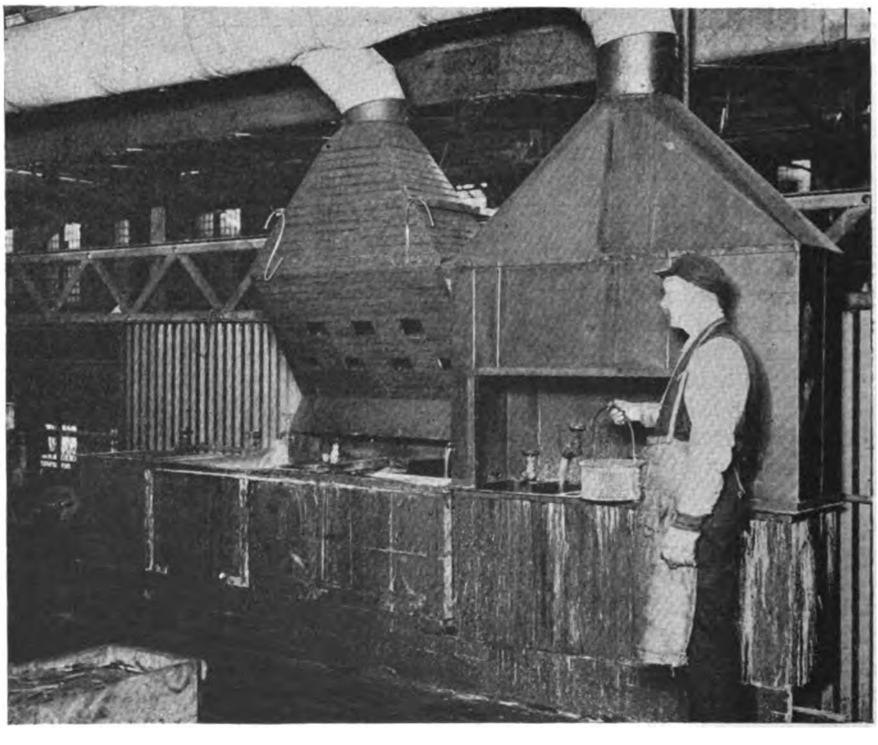
(2) The concavity of each surface of the copper bars must not vary more than 1 mil from the computed thickness; that is, the gaged thickness at any point must not be more than .002 in. less than the computed thickness.

(3) The convexity of the surface of the copper bars must not vary more than .0005 in.

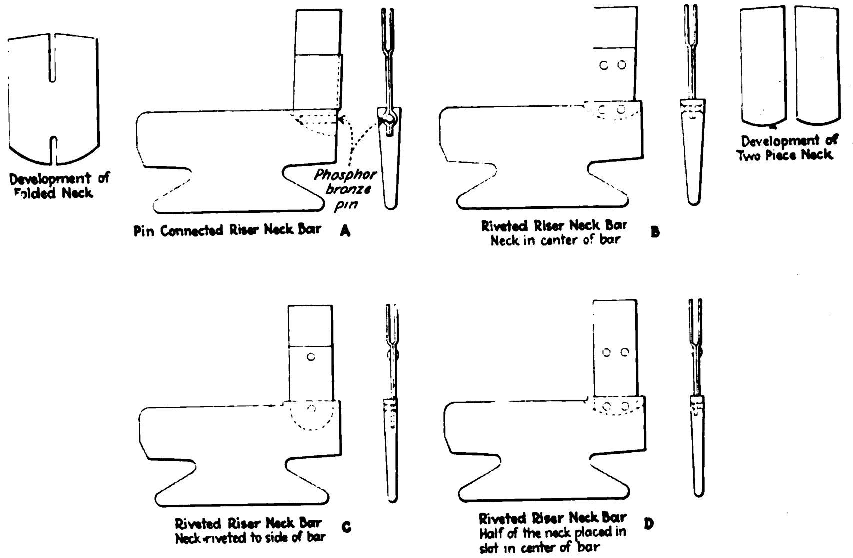
(4) All bars should have a drawn radius at the bottom chord. When a 1/32-in. mica extension is allowed in the bore, the combination of the two will give a large creepage between bars. On some motors the space between the bore of the assembled segments and the commutator spider is so small that it is necessary to machine the bore of the assembled segments. In such cases the drawn radius is of no value.

(5) All commutator bars should be chemically cleaned to remove all grease and dirt as is illustrated below.

(6) All commutator bars should



Cleaning bath in which the individual bars are dipped to remove all dirt and grease.



Here are four types of riser-neck commutator bars.

be free from roughness, cracks and laminations.

Commutator bars may be divided into two classes: namely, bars with solid necks, and bars with riser necks. The commutator neck is that part of the bar in which the leads are soldered.

Commutators which have the necks as an integral part of the bar are called solid neck commutators. The neck may stand several inches above the brush face, or it may be the same height as the brush face, as shown at *A* and *B* in the drawing on page 170. The neck is obtained by making a solid, tapered bar the same width as the bar and the neck. If the bar has a high neck the copper shown above the dotted line is cut out as is shown at *C* in the drawing on page 170.

This solid type of neck has advantages in that the necks being part of the bar no trouble is experienced from broken necks and, since the necks form a solid arch, no vibration is present to cause breakage.

Commutators which have the necks mechanically fastened to the copper bar are called riser neck commutators. There are two standard methods of connecting these necks to the bars: namely, "pin connected" and "riveted neck."

The pin-connected neck is used on commutators whenever it is possible, due to the simplicity of assembling. It consists of a folded neck and a phosphor bronze pin. You will notice in diagram *A* on this page that the neck is formed with a hole for the pin. The copper bars and mica strips are assembled and machined, after which a hole is drilled in the rear of each bar on the center line a definite distance below the top brush face. The depth of the hole depends on the width of the neck. After the hole is drilled the bars are slotted slightly wider than the width of the neck, and in the center. The depth and the radius of the bottom of the slot must conform with the design of the neck. The neck is then driven into the slot, the expanded place for the pin fitting into the drilled hole. The neck is expanded by driving a phosphor bronze pin into the hole, thereby holding it in place. In order to make a better electrical contact the necks, which are tinned before they are assembled, are soldered with pure tin solder at the rear of the commutator. A machine cut across the rear of the segments removes any excess solder and makes a smooth, finished surface.

The pin application of the connected neck is limited to commutators having a medium length brush face and diameter, provided the wall thickness is not less than the thickness of the mica strip. When the pin-connected necks cannot be applied, the rivet-connected type is used.

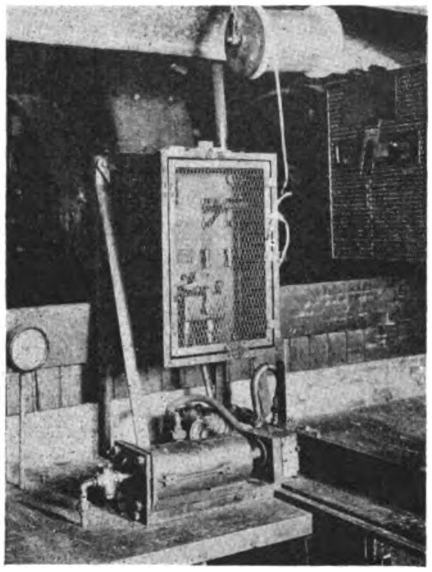
Rivet-connected necks have three different applications, depending upon the width of bar. When the bar is thick enough each bar is individually slotted in the center, wide enough for a folded neck or a double neck. The wall thickness must not be less than the thickness of the mica strip and the slot must be as nearly a half moon as possible, the radius being the same as that of the neck which must enter the slot as shown at *B* in the diagram above.

This shapes the slot so that it will hold the solder during the soldering operation, which is very important. After the bar is slotted the neck, which has been tinned, is placed in the slot and held in alignment with a special fixture while the two holes are marked with a center punch. This holds the necks in place while the holes are drilled. The neck is mechanically sustained by two soft copper rivets and soldered by heating the bar between two electrodes with electric current as shown in the illustration on page 172. When no electric heating device is available it is necessary to heat the bars by placing them between the two gas flame jets. Extreme care must be exercised when using a gas flame to prevent "sick copper," as previously explained.

Removing the burrs from both sides of the individual copper bars by grinding.

When the wall thickness is too small for a central slot to contain the two thicknesses of the neck, the side of the bar is slotted with an end mill as shown in *C* of the diagram on page 171. The neck is drilled while in the slot. It is then held to the bar by a soft copper rivet, after which it is heated by electric current between two electrodes and soldered. The wall thickness must not be less than twice the thickness of a mica strip.

Some bars are so thin that even the side slot method of fastening will not accommodate the two thicknesses of the neck. In such cases the bar is slotted in the center for the one side of the neck only. The other half of the neck does not enter the bar.



Electric heating device for soldering riser-neck commutator bars.

The air cylinder furnishes sufficient pressure for the low voltage to force enough current through the bar to heat it. The carbon contacts are water cooled. This permits quick chilling of the solder after the bar has been soldered.

This type of neck is used for very light service. The neck is held to the bar by a soft copper rivet, and soldered. This method is illustrated at *D* in the diagram on page 171.

All riser necks should be soldered with pure tin solder, the necks being tinned before soldering. Should the neck be soldered in a gas flame, the part of the neck which receives the heat must be retinned if the flame leaves the surface greasy, as this will make it very difficult to solder the armature leads.

Repair bars for riser neck commutators should be ordered from the factory with the neck assembled. However, a supply of riser necks may be carried on hand in case any should be broken.

Where a large number of bars of a given size are used, a punching die is employed to punch the bars to an unfinished size; that is, the V's are punched leaving 1/16 in. for finishing. All repair bars for these commutators are supplied in this manner when a die is available.

On a great many motors, however, the number of bars of given size is so small that it is cheaper to machine the V's from the rectangular bars after they are assembled, than it is to make a punching die. These bars are sawed into lengths corresponding to the unfinished bars, as shown in the drawing on page 169. These unfinished bars are called rectangular bars. For repair purposes rectangular bars should have the V's rough sawed, leaving 1/8 in. of material for finishing. Most bars for riser neck commutators are made from rectangular bars.

The following instructions describe the proper method of replacing damaged bars:

(1) Remove the damaged bars; use an undamaged adjacent bar for a pattern.

(2) Cut a new mica strip to the same size as the unfinished bar.

(3) Stick the mica strip to the copper with a thin coat of heavy, pure, orange shellac.

(4) Clamp the unfinished bar in a vise with a pattern bar.

(5) Trim it to approximately the outline of the pattern. If the V's have been rough sawed or punched, the amount of filing may be reduced by taking an extra cut with a hacksaw.

(6) Clamp the unfinished bar and the pattern in a vise with a mica strip between them. File the V's of the new bar to the same size as the pattern bar. The radius in the V's can be finished with a small rat-tail file. The bars are then ready to be placed in the commutator.

(7) Re-assemble the commutator, making certain that all the bars and the V-rings are in their proper places, and turn the commutator nut fairly tight.

(8) Heat the commutator to 125 deg. C. in an oven for several hours. While the commutator is still hot, apply a pressure of 20 to 30 tons to the V-ring and turn the commutator nut home. The method of assembling will be discussed later.

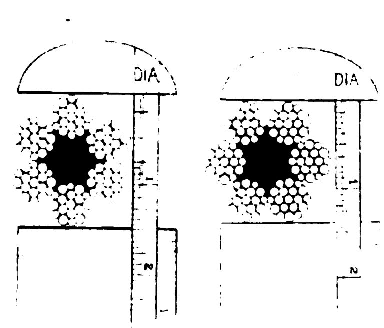
(9) Test for loose bars. A good method of testing for loose bars is to tap on the face of the bars at the front and rear. If a bar is loose, it will vibrate.

(10) Solder the leads in the commutator slots, turn the face of commutator and undercut the mica. Test for grounds and short-circuits.

Correct Method of Measuring Size of Wire Rope

THERE is only one way to measure wire rope correctly, and that is shown in contrast to the incorrect method, by the accompanying illustration furnished through the courtesy of the American Cable Co. The sketch at the left shows the correct method of measuring wire rope, as the greatest diameter determines the size.

It is highly important that the proper size of rope be employed, since an undersized rope will not give the degree of service that should reasonably be expected, while an oversized rope represents needless investment



This shows the correct and the incorrect method of measuring wire rope.

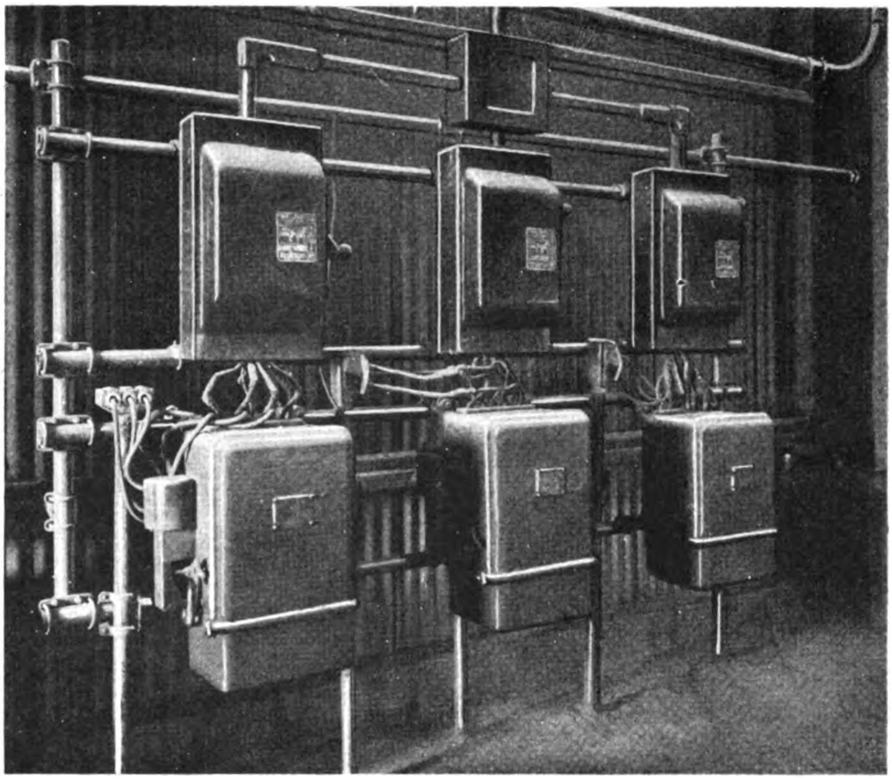
and will not properly operate over sheaves grooved for smaller ropes.

It is more important, however, to have the rope and the sheave properly fitted. No wire rope should be allowed to travel over a sheave wherein the groove is too small for its diameter. A pinching sheave will do more damage to a wire rope in one hour than a properly grooved sheave in an entire week, or more. Sheaves grooved 1/16 in. larger than the diameter of the rope will lengthen the life of the rope many times, as compared with rope life on pinching sheaves.

Since sheaves are cheaper than good wire rope, there is small economy in continuing the operation of improperly grooved sheaves or drums. Also the tread diameter of a sheave greatly affects rope life.

Mounting compensators on a pipe framework in this way facilitates inspection and repairs.

There is plenty of room to work on any switch or starter and any one of these units can be repaired or removed without disturbing the others.



Routine for

Inspection of Starting Compensators

By J. ELMER HOUSLEY

Electrical Engineer,
Aluminum Co. of America, Alcoa, Tenn.

IT IS SOMETIMES felt that a rugged piece of equipment, such as a motor starting compensator, that does not have any continuously rotating parts may be practically forgotten insofar as maintenance attention is concerned, but such devices almost always have an unpleasant way of calling attention to themselves under such conditions. Maintenance records covering many years indicate that about 60 per cent of compensator failures may be traced to bad contacts and bad oil, and about 30 per cent to insulation failure on the terminal and finger supports. The remaining 10 per cent of failures are caused by miscellaneous defects. Obviously, these percentages will hold only for the plant surveyed, and will vary according to the nature of the processes and the service requirements. The inherent possibility of each kind of trouble is present, nevertheless, in nearly every industrial plant.

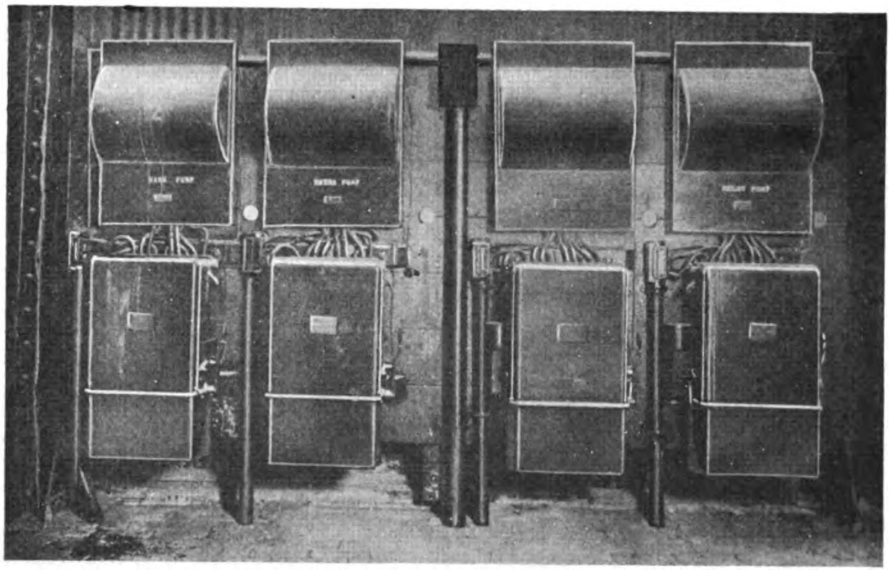
Frequently the construction and operation of the compensator are not understood by the plant maintenance men, and the equipment suffers thereby. It may be well, then, to say that the essential parts are two sets of stationary contacts and a movable element that makes contact with the stationary contacts. The function of a compensator is to start the motor on low voltage. It does this by first connecting the motor winding with an auto-transformer which is generally tapped to give starting voltages ranging from 40 to 75 per cent of line potential. After the motor comes up to speed the auto-transformer is disconnected from both the line and the motor and the latter is connected directly to the mains either through fuses or overload relays. The starting current is often taken directly from the mains without any form of overload protection during the starting period. This is the most satisfactory method.

Prior to 1922, treated maple was used for the wooden terminal blocks in compensators and the stationary contact fingers and movable contacts were secured to the maple blocks; flexible copper strips extended from the movable contacts to the stationary center terminal. The later designs of compensators use insulated steel rods for carrying the various contacts.

After a certain period of operation the contacts and fingers become pitted and burned, which tends to make poor contact. This may in turn overheat the wood or insulating material and cause a failure, and the oil becomes carbonized. In some cases single-phase operation occurs because of a burned contact on the running side; if the fuses are large a burned-out motor may be the result. Furthermore, the resultant bad condition of the oil may cause a short-circuit to the oil pan. This will burn a hole in the pan and may throw blazing oil over surrounding objects.

The second group of failures, caused by insulation breakdown between phases across the contact terminal board, may be ascribed to dirt, dust, conducting materials and water in the oil (collected during cold weather by condensation inside the steel case). All of this material gathers on the terminal strips and the resultant leakage current carbonizes the wood or insulating material until an arc may be maintained, which then becomes a destructive short-circuit. The necessity of periodic inspection has, therefore, a sound basis, as established in the foregoing discussion.

Although this discussion is not primarily concerned with the methods



In this case inspection and repair work are hampered by the manner in which the compensators and switches are mounted.

These units are mounted on boards. The oil pans of the compensators are too close to the floor and too close to the boards.

of mounting compensators, it may not be out of place to say that when such equipment is installed care should be taken to see that it is easily accessible for inspection and repair. A little forethought and planning at this time may save a good deal of inconvenience later on. One of the accompanying illustrations shows an installation in which some details of this nature were overlooked, with the result that the equipment is hard to get at for inspection.

The selection of the proper interval between inspections and the season of the year to make the inspection depends upon the operating conditions, the temperature exposure, and the duty cycle. A well-designed compensator operating under severe conditions should not require examination oftener than once in six months. For compensators in light service an examination once a year should suffice. The reason for indicating the proper season for inspection applies chiefly to compensators exposed to rapid and extreme temperature changes, whereby moisture that collects in the oil may freeze the mechanism and render it inoperative. From a protective standpoint the yearly inspection in this case should be made during the middle of the winter, and another one in the spring may be necessary.

The routine of inspection should comprise the filing or dressing of pitted contacts to put them in proper condition, and the replacement of thin or defective contacts. The oil should be changed once a year if it is dirty or carbonized. If the oil is clean and free from water it should be given a potential breakdown test, in cases where the operating voltage is above 440 volts. The oil should be removed and filtered if it tests below 22,000 volts, 30,000 volts being the optimum breakdown voltage with the test cup generally used. The oil pan should be cleaned and dried. All insulation should be examined for evidences of leakage current and should be cleaned. All terminals, studs and nuts should be carefully tightened to eliminate loose or hot contacts. The operating levers and mechanism should be cleaned and tested for proper and easy operation. Relays should be cleaned and worked by hand to make sure that they are in good condition. If fuses are used they should be examined and the contacts cleaned.

After reassembling, the compensator should be tested and the action of the low-voltage release observed. It should be put into good operating condition if it is found to be sluggish.

After having experienced the benefits that are to be derived from a routine annual inspection the maintenance crew of a plant could hardly be persuaded to return to the old method of waiting until the compensator blows up before looking at it.

Cutting Cost of Operating and Maintaining Lighting Systems

THE article by O. C. Callow in the February issue of INDUSTRIAL ENGINEER should be of interest to all industrial executives and engineers. It is of special interest to us, due to the fact that we recently discontinued the use of 110-volt lamps in part of our plant and are now using 115-volt lamps. This has resulted in quite a decrease in the total number of lamps used in the departments where this change was made.

After reading articles showing where production has been increased as much as 25 per cent by improving lighting equipment and increasing the intensity of the light, and articles showing where 18 per cent of all industrial accidents are due to poor lighting, it is easy to realize that the cost of artificial illumination is small compared with its importance in production and safety to workmen. Therefore, before we try to make a small saving in our lighting cost, we should be sure that we are really going to make a saving and that we are not sacrificing one thing for another.

The function of a lighting system is to produce an intensity of illumination of the correct amount and quality on the working plane. The efficiency or cost of a lighting system should be the cost per foot-candle of light or per lumen, for a given length of time. In checking the efficiency or cost of a lighting system all of the following factors should be considered:

(1) Intensity or amount of light.
(2) Cost of power.
(3) Cost of lamps.
(4) Cost of maintaining system, replacing lamps, cleaning equipment, etc.

It would no doubt greatly interest your readers to know what intensity Mr. Callow had on the working plane when he was using 115-volt lamps and what intensity he has now when using the 120-volt lamps. Also, what his maximum demand and cost of power were in both cases, and what his minimum, maximum and average voltage at the lamp is.

To check the saving that Mr. Callow made, I have taken his data and calculated the cost per lumen in

1924 and 1926. To do this it was necessary to make some assumptions. If they are incorrect or if I have made any mistakes, I shall be glad to have the correct data.

In making the following calculations I assume that the 250-volt lamps operated are on a.c. circuits, although it may be that all the 250-volt lamps are operated on a d.c. circuit. However, the following figures are about right, as the kilowatt-hours and lumens for the 250-volt lamps are about the same for both years. The main difference is the change from 115-volt lamps to 120-volt lamps.

Since Mr. Callow stated that there was a tendency for the voltage to rise to 118 volts at certain times of the day, I assumed the average voltage to be 116 volts on the 115- and 120-volt lamps, and 232 volts on the 250-volt lamps. I also assumed the average size of all lamps to be 130 watt. For 1924 only the total number of lamps installed is given, making it necessary to assume that 1,200 are 115-volt lamps and that 162 are 250-volt lamps.

The cost per lumen for 1924 was calculated as follows:

Connected load: 156 kw. of 115-volt lamps and 21 kw. of 250-volt lamps.

Demand: 158 kw. of 115-volt lamps and 18.7 kw. of 250-volt lamps.

The demand does not equal the connected load due to the fact that the line voltage is not equal to the rated voltage of the lamp; that is, 116 volts on the 115-volt lamps would increase the input to the lamps, whereas 232 volts on the 250-volt lamps would decrease the input to the lamp. Then we have:

Total demand, 176.7 kw.

Kilowatt-hours used per year (10 × 365 × 176.7), 645,000.

Cost of power per year ($0.01 × 645,000), $6,450.

Cost of lamps and labor for replacing, per year, $2,720.

Total rated lumens of 115-volt lamps (1,900 × 1,200), 2,280,000.

Total rated lumens of 250-volt lamps (1,400 × 162), 227,000.

Total actual lumens of 115-volt lamps (103.3 × 2,280,000), 2,355,000.

Total actual lumens of 250-volt lamps (0.77 × 227,000), 175,000.

The actual lumens do not equal the rated lumens due to line voltage not being the same as rated voltage of lamp.

Total lumens, 2,530,000.

Total cost, $9,170.

Cost per lumen per year, $0.00363.

The cost for 1926 was as follows:

Lamps installed: 120-volt lamps, 1,295; 250-volt lamps, 161.

Connected load: 168 kw. of 120-volt lamps and 21 kw. of 250-volt lamps.

Demand: 161 kw. of 120-volt lamps and 19 kw. of 250-volt lamps.

Total demand, 180 kw. Kilowatt-hours used per year, 657,000.

Cost of power per year, $6,570.

Cost of lamps and labor of replacing them, $1,800.

Total rated lumens of 120-volt lamps, 2,460,000 and of 250-volt lamps, 225,000.

Total actual lumens of 120-volt lamps, 2,165,000 and of 250-volt lamps, 171,000.

Total actual lumens, 2,336,000.

Total cost, $8,370.

Cost per lumen per year, $0.00358.

Although Mr. Callow shows a saving of 38 per cent in the total cost of lamps and replacement of lamps, the above figures show that he is saving only about 2 per cent in the cost of lighting his plant. If the loss due to burning the lamps 1,400 hours instead of 1,000 hours could be calculated, I believe that we could show that Mr. Callow paid more for his light in 1926 that in 1924. Also the losses that cannot be figured are decrease in production and possible injury to workmen due to the fact that the intensity on the working plane was decreased about 15 per cent when the 115-volt lamps were replaced with 120-volt lamps.

To get the maximum efficiency out of a lighting system the line voltage should equal the lamp voltage, which would result in an average lamp life of 1,000 hours if all lamp failures were due to burning out.

The data in Mr. Callow's article show that he was getting about maximum efficiency out of his lighting system in 1924 due to the fact that average lamp life during that year was about 1,000 hours. For efficient operation in 1926 Mr. Callow should have used about 5,314 lamps having an average life of 1,000 hours instead of 3,795 lamps having an average life of 1,400 hours, providing no lamps were broken or stolen.

All plants have special problems and difficulties that must be solved and overcome. If this was the case with Mr. Callow, he may have other good reasons for changing from 115- to 120-volt lamps. If the saving in cost of lamps used was his only reason for making the change, the loss in efficiency due to lamps burning 1,400 hours, the loss in production and possible loss due to injury will just about equal what he saves in the cost of lamps.

I believe that articles like Mr. Callow's are a great help to anyone interested in efficient plant operation, and I am sure that all the readers of INDUSTRIAL ENGINEER would be pleased to see more articles of a similar nature.

G. R. KILBOURN.

Chief Electrician,
Marion Steam Shovel Co.,
Marion, Ohio.

* * * * *

MR. KILBOURN'S remarks regarding my article in the February issue of INDUSTRIAL ENGINEER, are very interesting, especially his method of calculating the cost of a lighting system in lumens per year.

Inasmuch as he has made several assumptions in his calculations that are not correct in this instance, I have worked out the cost per lumen per year for 1924 and 1926 from the figures I have available and will also answer the several questions he sets forth.

In the first place, I wish to say that the figures given in my article are taken from the lighting costs of a blast furnace and coke plant. As anybody familiar with these types of plants will know, there is little if any fine work involved where the intensity of illumination is high. In our machine shop and electric shop the intensity is about 4 foot-candles, and in the power house about 3; the remmainder of the lighting is in conveyors, around furnaces, cast house and stoves, boiler house, pig machine, ore bridge and yard coke battery, and general outside lighting.

No change has been noticed in the intensity since the lamps have been changed from 115 to 120 volts. Furthermore, our records of personal injury have shown a decrease in the last two years and our production of pig iron has certainly not been decreased owing to the economies made in our lighting system.

With reference to the following calculation, I would say that the average a.c. voltage on the 120-volt lamps is 117, and the average d.c. voltage on the 260-volt lamps is 255.

Inasmuch as power is produced from byproducts, coke-oven and blast-furnace gas, coke breeze, tar, etc., in the plant, I have cut in half the figure used by Mr. Kilbourn in his calculation for the cost of power.

In order to make a better comparison between the cost of lighting the plant in 1924 and 1926 I have based my calculations upon the same number of lamps installed in 1926 as in 1924, omitting the extra 94 lamps that have since been installed on new work. The comparison is

Comparison of Cost of Lighting in 1924 and 1926

For 1924

Total lamps installed	1,362
Number of 115-volt lamps	1,177
Number of 250-volt lamps	185
Connected load a.c., kilowatts	153
Connected load d.c., kilowatts	14
Total connected load, kilowatts	167
Demand of a.c. lamps, kilowatts	155.6
Demand of d.c. lamps, kilowatts	14.28
Total demand, kilowatts	169.88
Kilowatts used per year (169.88 × 365 × 10)	620,135
Cost of power per year (620,135 × $0.005)	$3,100
Rated lumens of a.c. lamps (1,177 × 1,900)	2,236,300
Rated lumens of d.c. lamps (185 × 1,400)	259,000
Actual lumens of a.c.	2,274,317
Actual lumens of d.c.	264,180
Total actual lumens	2,538,497
Total cost of power	$3,100
Total cost of replacements	$2,720
Cost of lighting system	$5,820
Cost per lumen per year	$0.00229

For 1926

(Number of lamps installed same as in 1924)

Connected load a.c., kilowatts	153
Connected load d.c., kilowatts	14
Total connected load, kilowatts	167
Demand of a.c. lamps, kilowatts	150
Demand of d.c. lamps, kilowatts	13.7
Total demand, kilowatts	163.7
Kilowatts used per year	597,505
Cost of power used	$2,987
Rated lumens of a.c. lamps	2,236,300
Rated lumens of d.c. lamps	259,000
Actual lumens of a.c. lamps	2,181,100
Actual lumens of d.c. lamps	254,080
Total actual lumens	2,435,180
Total cost of power	$2,987
Replacements, 1,362 lamps at $1.24 per outlet	$1,688
Cost of lighting system	$4,675
Cost per lumen per year	$0.00192

given in the accompanying table.

We find that with the same number of lamps installed the cost per lumen per year has decreased from $0.00229 in 1924 to $0.00192 in 1926, showing a saving of 16 per cent per lumen per year.

There is a loss of about 4 per cent of the actual lumens in 1926 owing to the use of the higher voltage lamps, but a saving of $1,145 is shown in 1926, representing 19-½ per cent.

We must not overlook the fact that the changing of the voltage on the lamps is not responsible for all of this saving, as several other improvements were made in the lighting system between 1924 and 1926, as described in my article.

I wish to thank Mr. Kilbourn for his discussion of my paper, as it is this kind of interest that brings out many points that may be overlooked or passed over in a paper.

O. C. CALLOW.

Chief Electrician,
Trumbull-Cliffs Furnace Co.,
Warren, Ohio.

Markings on Roof That Show Location of Leaks

AT A New Jersey factory manufacturing printing machinery, a series of numbers are painted on the roof. These seem odd to visitors until their purpose has been explained. The numbers correspond with the numbered posts or columns that are directly underneath, regardless of whether the building is one or more stories high. Wherever it is possible to do so, the numbers are painted upon a riser or other upright part nearby.

The purpose of this numbering is to locate leaky spots more readily. Irrespective of how good a roof may be, it is going to leak at times due to a cracked glass, a spot rusted through under the paint, a sheet of prepared roofing that has become brittle through long wear, or any of the other little things like these that let in enough water to damage valuable stock. A driving storm will find all the leaks, both large and small.

Men cannot repair leaks during a storm and often it is a day or two after a storm before it is possible to make a good repair, even if the trouble is followed up quickly.

In this plant, every post is numbered. Whenever a leak is discovered its location can be noted exactly, as for example, 12 ft. northeast of post 82. With such information the repair crew can go directly to the spot on the roof. The numbers on the roof are near enough to the posts to form as accurate a guide as is necessary. Foremen are instructed to note leaks in their departments and to report them by location.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Repairing Workbench with Minimum Interruption

THE method used to repair about 80 ft. of workbench in a machine shop, may be of interest to the man with a similar problem in some other plant. The old bench had been made of soft, yellow pine which had worn and been cut away on the surface until it was neither level nor usable, and the men were complaining of the slivers which they got into their hands. The first plan proposed was to tear out the old bench top and put in a new one. It was thought, however, that this would interfere too much with the bench hands.

Finally the foreman of the Maintenance Department noticed that the bench top appeared to be somewhat low, because the men had to stoop at their work. Therefore, instead of tearing off the old top and keeping the men from their work for some time, he suggested that the new planks be put on top of the old ones. The foreman of the department, when the low bench height was called to his attention, readily agreed to this. The old bench was 33 in. high, while 36 in. is considered a better bench height.

Accordingly, 3-in. dressed maple planks were mounted on top of the old pine planks by lag bolts screwed in from beneath. One section was done at a time; so the work of the bench hands was hardly interfered with. The cost of this job was estimated at about one-half of what had been anticipated when it was thought that the entire bench top must be removed. In addition, there is the added benefit of a more comfortable working height for the men.

What have you done with Electric Arc Welding?

Here is an opportunity to obtain recognition for your accomplishments

ONE of the finest examples of co-operation between a manufacturer and users of equipment has just come to my attention in the announcement of the Lincoln arc-welding prizes by the American Society of Mechanical Engineers. Because I feel sure that there are a number of readers of this publication who can compete for these prizes, I want to give you in brief the details of the competition and urge you to enter it if you are interested in, and have had some experience, with arc welding.

IT IS stated in the announcement that the American Society of Mechanical Engineers has accepted the custody of $17,500 offered by the Lincoln Electric Co., Cleveland, Ohio, to be awarded by the society in a world-wide competition for the best three papers disclosing advancements in the art of arc welding, that are submitted under the rules of the competition. Three prizes will be awarded; namely, $10,000, $5,000 and $2,500.

THE purpose of this competition is to encourage the art of arc welding, to point out new and wider applications of the process, to discover improved methods of testing welds, and to indicate the advantages and economies to be gained by its use. Anyone in any country of the world may compete, and about nine months are allowed for the preparation of the competing papers, as the closing date of mailing is Jan. 1, 1928.

HERE is a real and rare opportunity to work for a worth-while prize and besides play a part in a world-wide endeavor to promote a process that not only has well-recognized mechanical advantages, but the possibilities of enormous savings to industry when it is more widely applied. To be identified with a competition of this sort is a distinction to be recognized, aside from the liberal cash awards that are offered.

THINK back and review the early development work in the application of electricity, and consider the comparatively slight knowledge of the subject then possessed by even the leading authorities. Or, come closer to our own day and compare the metals and manufacturing processes of ten years ago with those now found in the modern automobile factory, for example. Then you get a picture of the opportunity that lies before anyone who can still further devise ways and means to reduce the cost of manufacturing methods and speed up manufacturing processes. In such ways and means electric welding is certain to be an important factor.

IN THE minds of those who have used electric welding, little doubt can exist that it will eventually replace riveted construction for many purposes, and make it possible to do away with many of the complicated, costly, and needlessly heavy machine frames now made of cast iron. The savings in weight, labor and material costs, combined with equal or greater mechanical advantages, will demand this progress by the force of competition alone. And so this subject is a timely one for study and specialization. Who knows but that there may arise a new profession and title of Electric Welding Engineer that will carry the same responsibilities in manufacturing industries as the Metallurgist and Chemical Engineer do in the metal-refining industries?

ASSUMING that you are looking into the future and have the inclination and ability to do pioneer development work, here is an opportunity you cannot afford to pass by. Write to the American Society of Mechanical Engineers at 29 West 39th St., New York City, and ask for a copy of the 18-page booklet outlining the conditions governing the award of the Lincoln arc-welding prizes.

Practical Pete

P.S. IF YOU are a reader of INDUSTRIAL ENGINEER and want to enter this competition but cannot decide on the best way to get data or conduct an investigation, just write me a letter and I shall be glad to give you all the help I can. I have a number of ideas right now that I should like to pass on to someone. P. P.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, Editor

Maintenance Work Is Coming Into Its Own

ONE of the best signs of the increasing regard which the management of industrial concerns is according to the maintenance and operating departments and their activities is the tendency to provide better quarters and equipment for them. In times past, when maintenance was looked upon somewhat as a necessary nuisance that must be tolerated because machines would break down, the maintenance department was usually housed in some out-of-the-way building, or in a dark and dreary section of the plant that was least adaptable to manufacturing, and for equipment often had to depend upon machinery cast off from the production departments.

In visiting maintenance and operating departments, one is impressed with the number of instances where they occupy ample space in bright, cheerful surroundings, often in a section of a new building, in which their needs have been carefully considered in the space and equipment provided. This is true in many places instead of in merely a few instances.

Such acknowledgment of the importance of the responsibilities connected with proper maintenance and operation was inevitable when the increasing value of these activities is considered in regard to their effect upon uninterrupted production.

Prove the Value of Your Ideas

OPERATING executives who fail to secure adoption of a cherished plan, are often inclined to blame the management for not taking advantage of a good suggestion. Sometimes the fault lies, to a certain extent, with the executive himself, because he does not put his suggestions in a form that will appeal to the management.

This is well illustrated in one instance where the chief electrician in a factory found, after a careful study, that with a new type of reflector and some adjustments as to spacing and lamp heights he could increase considerably the amount of light on the working area. However, he was much discouraged when his superior merely said, "That's fine; now how many lights can we take out?"

Managers these days are continually looking for methods that effect a saving, in order to meet the stiff competition they must face. This manager, no doubt without thinking, compared light to a machine: if the production of a machine is increased, fewer machines will be required. Probably if he had stopped to think, he would have realized that this reasoning was incorrect, because the analogy does not apply to lighting problems.

Perhaps if this Chief Electrician had approached his superior with a little more explicit information as to what might be expected from the increased light, he would have received his appropriation without further questioning. For example, he could have obtained data on the decrease in the time required to read or set micrometers, to take measurements, or to set up tools. Or, he could have cited the increase in quantity and quality of production that have been obtained in a number of installations which have been described in this and other technical publications.

These and other methods of "selling" the management on better lighting have been used successfully. Practically every plant manager will listen sympathetically to a plan to save money even though it requires expenditure of money to put it into effect. However, the story must be complete and thorough, and have dollar-saving facts behind it.

Check Switch Ratings Carefully for Double-Squirrel-Cage Induction Motors

ALTHOUGH across-the-line motor starting switches of either the hand-operated or the magnetic type operated by a push button are usually shown in catalogs with their ampere and horsepower ratings, it is seldom safe to specify a starting switch by reference to the horsepower rating of the motor only. This is now particularly true when the so-called double-squirrel-cage or other design of self-starting induction motor is being used. The full-load or running current of a standard induction motor of 5-hp. rating, say, operating at 220 volts, 60 cycles, three phase is usually known to be under 15 amp. in most designs, and it has usually been safe to specify a starting switch for such a motor by the horsepower rating.

In the case of a 5-hp. double-squirrel-cage induction motor, however, the full-load or running current at 220 volts, 60 cycles, three phase and 1,200 r.p.m. may be 16 amp. and at 900 r.p.m. 18 amp. or more, and a switch with overload relays capable of handling this service must be used. Again, owing to the use of thermal overload relays in all the various types, except those that are adjustable over fairly wide limits, it is also essential that the exact full-load current rating of the motor be used to obtain the proper setting of the thermal elements for safe overload protection.

Because it is easy to make errors in switch applications when motors and switches are drawn

out of the storeroom stock in a large plant, records are usually kept that give more or less complete information. Such records that apply to the standard, squirrel-cage motor should now be revised so as to make sure that adequate switch capacity is provided for the newer designs of double-squirrel-cage motors that are becoming more and more popular on high-torque starting loads. Failure to do this will certainly damage the switch and perhaps the motor, causing delays that may be expensive but can easily be avoided by a little precaution.

These newer types of motors may come into your plant without your knowledge on such machinery as pumps, air compressors and the like, the motors being furnished by the manufacturer. In such a case the record of the motor characteristics should be obtained before the wiring for the installation is laid out and the starting switches are ordered.

Teach Your Men the Prone Pressure Method

CONSIDERABLE publicity recently attended the efforts by the employees of a public utility company in the Middle West to save the life of a fellow worker who was suffering from a rare form of paralysis that affects the diaphragm and muscles used in breathing. Men working in shifts kept this patient alive for several days by forcing respiration through the rythmic application of pressure, alternating with a momentary relaxation.

Although these efforts were, unfortunately, not successful in restoring the patient to health, they demonstrated in striking fashion the possibilities of artificial respiration.

Enough instances have occurred where after a shock no indication of breathing or heart action could be found, but the life of the person was saved by the use of the prone pressure method of resuscitation, to justify the statement that every man working around electrical equipment should have experience in the use of this method.

One large industrial organization is training several thousands of its men and women employees in the application of this method because it has proved its value not only in cases of electric shock, but also in drowning, asphyxiation, and so on.

In some plants the man in charge of the electrical work considers that it is sufficient for him alone to know what to do in case of accident. Then the question inevitably arises, What would happen if he were the victim of an accident?

A much safer course is to see that every man in the electrical department is thoroughly familiar with the prone pressure method and is kept in practice by frequent demonstrations.

Opinions Are Not the Solution of Power Drive Problems

AN OPERATING executive in an industrial plant recently remarked that some important changes were being held up because he could not decide whether to use group or individual drives for the machines. A question as to the steps he was taking to solve this problem disclosed that he was getting the "opinions" of various men on this subject.

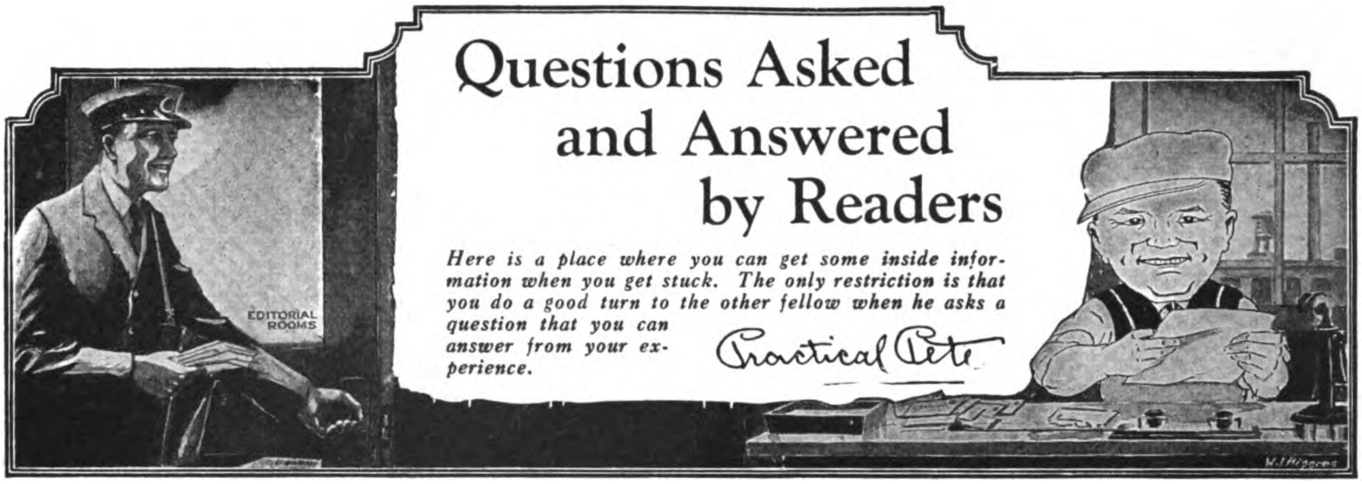
The relative merits of group and individual drives have been discussed at great length during the past few years, and some very important points have been brought out. In actual service both types of drives have proved their worth, when properly applied. Both have their advantages and disadvantages: their defenders and their opponents. Neither is a universal panacea for all operating troubles.

Every operating executive must occasionally decide which type is the better to use under given conditions. This is a very important question. It is by no means something that can, or should be, decided on the basis of prejudice, argument, or hearsay. Stated simply, the problem is to determine how power can under the existing conditions be transmitted in the most economical and satisfactory manner from the motor shaft to the shaft of the driven machine. Fundamentally this is an engineering problem, and it can be solved correctly only by the same procedure that is followed in solving other engineering problems: by proper consideration and analysis of the facts in the case.

The operating requirements of the drive or drives must be clearly defined. Then, assuming that one has a sound, practical knowledge of the possibilities and limitations of the methods and equipment available for power transmission, the selection of the drive is a matter of balancing the investment, operating and maintenance costs, and all other pertinent factors, of one type of drive against the other. An analysis of this character will usually make it possible to select the most suitable drive intelligently and with the minimum of guesswork.

Every installation must in general be given individual study, and any decision should be based on the conditions peculiar to that installation. Therein lies the danger of relying too much on the opinions or experiences of others. Conditions may differ so much that a drive that is well suited to one plant may not be the best or most satisfactory for another plant.

Opinions may be very helpful, but unless they are based on experience with, and apply to, installations that are comparable in all important respects, it is much safer to check them against an analysis based on known facts.



QUESTIONS

Who Can Answer These?

Trouble in Setting Circuit Breakers

We have had difficulty in accurately setting our three-phase, 550-volt oil circuit breakers, which range from 80- to 400-amp. rating. I shall appreciate it if readers will tell me the best method of making this adjustment, by the use of a phanton load. Can a water rheostat be used as the load, or is some other device more suitable?
Vancouver, B. C., Can. A. M. S.

Changing Single-phase Motor for Three-phase Operation

I have a 2-hp. single-phase, 110/220-volt, 1,725-r.p.m., 60-cycle, repulsion-reduction motor that I wish to operate on a three-phase supply. I do not want to rewind the rotor if I can help it, but should like, if possible, to increase the horsepower rating, keeping the speed the same as before. The motor drives a lineshaft from which we operate a small lathe, a drill press and an emery wheel. What will I have to do to this rotor to change it for three-phase operation? When the motor is operated three-phase, will the starting torque be greater or less than it was on single-phase operation?
Farmland, Ind. A. G. B.

Polarity of Interpoles

I do not thoroughly understand the rule governing the polarity of interpoles and wish someone would explain how it works out under different conditions. For example, on machines that have two interpoles, I have often found them to be of opposite polarity. Was this polarity correct? Can one rule be made to apply to a motor having any given number of main poles and interpoles? I shall be grateful for your help on this question.
Mohiland, Utah. K. W. F.

Cost of Interior Painting in Mill-Type Building

Our main building has not been painted on the inside for several years and needs it badly. It is a four-story mill-type building with sawtooth roof. The area of each floor is about 25,000 sq.ft. The ceiling and upper part of the walls are to be painted mill white and the lower part of the wall a dark brown I should like to get the experience of other readers on the use of air paint guns on such construction, and what they think such painting should cost per sq.ft. Also, what should brush painting cost? Any information you can give me will be appreciated.
Springfield, Mass. B. W.

Oil Grooves in Bronze and Babbitt Bearings

We rebuild our bearings and I wish that readers would tell me the best form of grooves to cut in oil-lubricated bronze and babbitt bearings up to 3-in. bore, for shaft speeds of about 300 to 1,800 r.p.m. I should like to know how grooves should be cut in both solid and split bearings. When should straight and when should criss-cross grooves be used? How wide and how deep should grooves be cut? How should grooves be cut for grease lubrication?
Scranton, Pa. B. V. W.

Eliminating Radio Interference from D. C. Generator

Interference with radio reception in our community has been traced to one of our 100-kw., 230-volt, 275-r.p.m., Type N, engine-driven Westinghouse generators. We ground the commutator and adjusted the brushes and holders so that there is no sparking, but the only way that the trouble can be stopped is by pulling the main switch, or by reducing the voltage from 230 to 160. When the voltage is raised, the trouble returns. The radio interfence seems to be greatest at one end of the engine stroke; in town it is possible to count the revolutions of the engine on a radio set. I believe that the engine speeds up at the end of one stroke, thereby increasing the generator voltage. If condensers are a practical remedy for the trouble, what size should they be? How should they be connected to the generator? What other method could be used to rectify the trouble? We are very anxious to get this situation cleared up and I shall appreciate any help you can give me.
Vandergrift, Pa. G. J. K.

ANSWERS

Received to Questions Asked

Checking the Alignment of Lineshafts

I have always heard that in checking the alignment of a shaft, the belts should be thrown off. It seems to me that the belts should be left on the pulleys to give the approximate operating conditions. In other words, a belt may draw a pulley and shaft and its bearing to one side in operation, but if the belt is off, the shaft may appear to be in line. I believe that the alignment should be checked as nearly as possible under operating conditions. I wish some of our readers would discuss this question.
Moline, Ill. H. J. K.

In reply to H. J. K., shafts could be aligned with the belts on the pulleys, but it would be almost as much of a running approximation as it is to align without the belts on. The moment the machinery is put to work various changes and deflections take place which destroy the alignment made when the shaft is idle, with belts either on or off. Machines starting and stopping, running idle or on peak loads, bends that may exist in the shaft itself, moving loads on the floor or other floors—these are some of the things that would affect the alignment previously made.

If a shaft were aligned for certain belts on at any one time it would have to be re-aligned if other belts and pulleys were put on. Belts that have been running somewhat loose may be taken up and, if the shop men prefer belts snapping tight, the replaced belt will draw the shaft to one side until the leather stretches again.

This assumes the use of shafting of ordinary sizes. It would be possible to install large shafts that would be so stiff that they would not be susceptible to belt pull to any appreciable extent, but that would be poor engineering and expensive for all time.

Self-aligning bearings in the hangers do away with the dire effects of the shaft springing under loads. Except where an extremely light shaft has been put in by uninformed persons or where the load carried has been multiplied, there is very little trouble from belts pulling it out of alignment, because of the elasticity of the shaft and the self-aligning feature of the bearings. The need for this was early recognized and fixed bearings were changed to swiveling bearings.

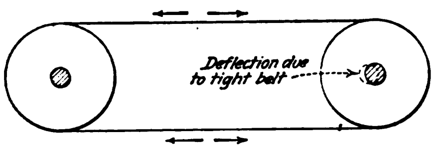
Shafts are seldom so straight that a line 100 ft. long does not show an

eccentricity at some point. The weight of the steel itself causes a certain deflection. A $3\frac{7}{16}$-in. shaft with hangers spaced 8 ft. apart will sag nearly $\frac{1}{32}$ in. from its own weight, if measured half way between the hangers.

Probably the greatest stress put on a shaft is when a big belt is snapped in place. This may be indicated by the accompanying diagram. It is not at all uncommon for a belt to be broken apart, either in the leather or at the joint, when it is forced on when too tight.

Assume for illustrative purposes that the shafts cannot turn and that the grip of leather upon metal is such that each half of the belt becomes a rod in tension; then the stresses in the belt are as indicated by the arrows in the diagram and the shaft will be deflected as shown. Assume further that this is an 8-in. belt midway between hangers on 8-ft. centers and the shaft is $3\frac{7}{16}$ in. Roughly, belting breaks at 3,000 lb. pull per sq.in. of section.

This 8-in. belt therefore presents $8 \times \frac{1}{4} \times 2$, or 4 sq.in. of leather for the load, if the thickness is $\frac{1}{4}$ in. At half the breaking strength, this represents a pull of $1{,}500 \times 4 = 6{,}000$ lb. A load of 6,000 lb. on this shaft is the same as that of a beam resting on supports at the end, because of the swiveling of the bearings. This creates a deflection of 0.527 in. at the center. This is an extreme case, theoretical only, but it does not show a startling deflection for a slow-speed shaft, and many things would lessen this spring in practice; for instance, there would not be that amount of pull between two shafts with that size of belt properly installed, and, if the length were coupled up in a line, the adjoining sections would exert some straightening or stiffening influence.



This shows the conditions produced by putting on a belt that is too tight.

Inasmuch as we cannot align shafts while the loads are on them, we obtain the best approximation by doing it with a stripped shaft. If the shaft and hangers are selected of a size in accordance with good practice, there will be no serious trouble unless conditions are much out of the ordinary.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.
Middletown, N. Y.

Connection for Ammeter and Relays

I should like to know what connection to use on a circuit containing an ammeter, two current transformers, two trip coils for an oil circuit breaker, and some kind of switch that will permit switching the ammeter so as to read the current in each phase of a three-phase circuit. Can I read the current flowing in the third phase when using only two current transformers?

Chicago, Ill. A. W.

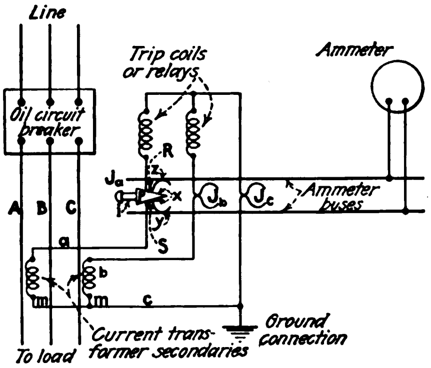
REFERRING to the question asked by A.W., it is assumed that by "relays" he means the trip coils of the circuit breaker. The desired result may be obtained if the connections are made as shown in the accompanying diagram. The details are shown more or less conventionally since there are available, through switchboard manufacturers, standard ammeter switches which accomplish the result indicated in a simple manner with a minimum number of connections. The questioner is referred particularly to the catalogs and publications of the Westinghouse Electric & Mfg. Co. and the General Electric Co. for more detailed information. The accompanying diagram is simple, but a few words of explanation may not be out of place.

Current transformers are inserted in lines *A* and *C*, care being taken to note the polarity marks so that both are at the same end as *M*. The secondary leads are connected two in common at the same end, and the other two leads *a* and *b* are carried to the trip coils by way of the ammeter jacks *J*. The common secondary lead *c* is carried to the common trip coil lead forming the return circuit *c* through a third ammeter jack. The jacks, J_a, J_b and J_c are shown conventionally, as they are similar to ordinary telephone jacks, so that the method may be more easily understood.

Plug *P* has a metal point and insulated sections at *x;* should it be desired to read the current in line *A*, the plug is inserted in the receptacle for jack J_a; the jack is so tapered that contact is made at *y* and *z* with the ammeter buses before the insulated section of the plug separates the sections *R* and *S* of the jack and when the plug is further inserted *R* and *S* separate, allowing the current to flow through the ammeter, as indicated by the arrows.

The currents in lines *B* and *C* may be read by inserting the plug successively in jacks J_b and J_c. The arrangement indicated in the diagram is similar to the method used on arc circuit boards.

As previously stated, the jacks have been illustrated to show the principle involved; as a rule some form of switch is used on most switchboards by means of which the different currents may be read by turning a single handle to any one of three positions. The common lead *c* should always be positively and securely grounded. As a further precaution, the contacts *R* and *S* should be carefully tested to avoid any possibility of opening the secondary with full-load current flowing in *A*, *B* or *C*, for such a condition would give rise to dangerous operating conditions.

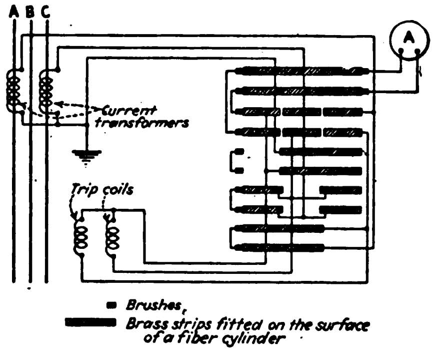


This connection scheme shows how one ammeter may be used to indicate the current flowing in phases *A*, *B* or *C*.

C. O. VON DANNENBERG.

Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

IN REGARD to the question asked by A.W., one ammeter can be arranged to indicate the current flowing in the different phases of a three-phase circuit. Although only two transformers are used, it is possible to obtain a reading of the current in the third phase, for in a three-phase system the current flowing at any instant in any one of the three phases is equal to the vector sum of the current flowing at any instant in the other two phases. For instance, the current in phase B is equal to the vector sum of the current flowing in phases A and C.



Method of connecting one ammeter to a three-phase circuit through a three - way secondary transfer switch, to permit measuring the current in any one of the three phases.

The illustration shows the method of connecting one ammeter to a three-phase circuit, using two current transformers, so that the ammeter can be readily switched to indicate the load on the desired phase. In order to do this, it is connected to a three-way secondary ammeter transfer switch which is in turn connected to the two trip coils and the two current transformers.

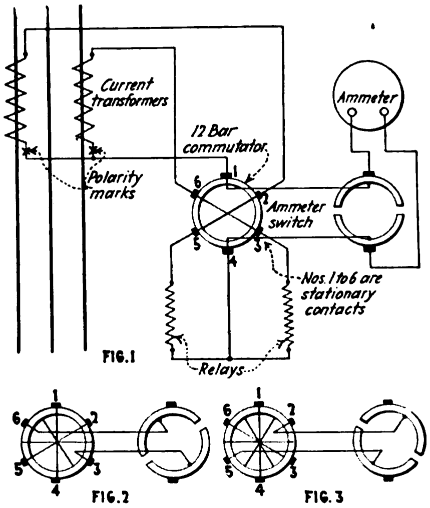
Chicago, Ill. A. NOEPPEL.

IN ANSWER to A. W.'s question, the connections of an ammeter switch to two current transformers and an ammeter are shown in the accompanying diagram. The trip coils of the oil-switch are sometimes connected through relays or connected as straight series trip coils. In the latter case, the trip coils, if designed for 5 amp., would be placed in circuit where the relay coils are shown.

The ammeter switch resembles the commutator and brush rigging of a generator, on a small scale. The commutator has 12 segments all of which except two are cross-connected: these

two are extended to a two-segment commutator. The 12 segments operate under six stationary contacts that are connected to the transformers and relays as shown in the diagram, and the two-segment commutator operates under two other stationary contacts that are connected to the ammeter.

The commutator can be rotated only through a small arc, and in this distance there are three positions each of which places the ammeter in each of the three different phases. Fig. 1 shows the switch set in its centre position in which the ammeter is connected in circuit with the common wire from the two current transformers, and will thus indicate the current flowing in the middle wire of the three-phase system. If the switch is turned to the



This ammeter-transfer switch will connect the ammeter to any one of the three phases.

Fig. 1 shows the switch position for obtaining a reading in phase B. The ammeter can also be connected to either of the other two phases, as shown in Figs. 2 and 3.

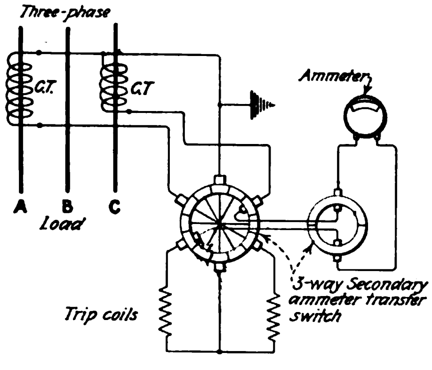
left or right of the centre position, the ammeter will accordingly be connected in circuit with one of the two current transformers, as indicated by Figs. 2 or 3, thus indicating the current in each of the other wires.

As the switch is rotated, provision is made for short-circuiting the transformers while passing from one position to the next.

ERNEST DICKINSON.

Kimberley, B. C. Can.

THE question asked by A.W. need cause him no worry, as it is entirely feasible to use two current transformers in a three-phase circuit to obtain ammeter readings in all three phases. He will need a special ammeter transfer switch such as a Westinghouse Type R. S. Style No. 279,056 or a General Electric Catalog No. 2,192,182-G1. With either of these switches the ammeter can be cut into any phase without opening the secondary circuit from the current transformers. The trip coils to operate the oil circuit breaker can be operated from the secondary circuits of the same current transformers. The accompanying diagram



Method of connecting one ammeter to a three-phase circuit so as to indicate the current in phase A, B or C.

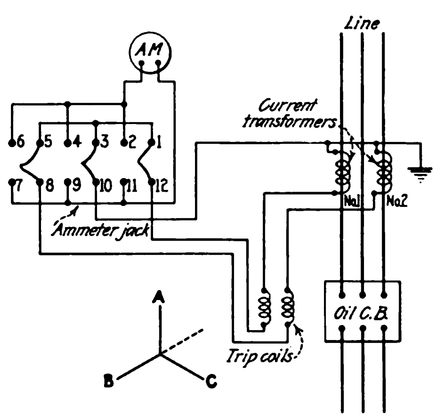
shows the manner of connecting a G.E. ammeter transfer switch so as to obtain ammeter readings in any phase, at will, by merely turning the handle of the transfer switch.

Electrician, CHAS. A. PETERSON.
Fairbanks Exploration Co.,
Fairbanks, Alaska.

ANSWERING A. W.'s inquiry, the current in the third phase leg can be read when two current transformers are used, with the connections shown in the accompanying diagram. It is easy to see how the current may be read in phases A and C, as current transformers are connected in these. The principle of reading the current in phase B can be shown by a simple vector diagram wherein the two outside current readings are 120 electrical degrees apart; therefore, the current in phase B would be the resultant.

To make use of the accompanying diagram, I recommend that A. W. first purchase a factory-built, ammeter jack. There are a number of these on the market, made by the leading electrical manufacturers. As there is an element of danger in handling current transformers, I would not recommend the use of a home-made device, unless the user has excellent facilities for building such apparatus.

Referring to the diagram, the method of using the jack is as follows: To



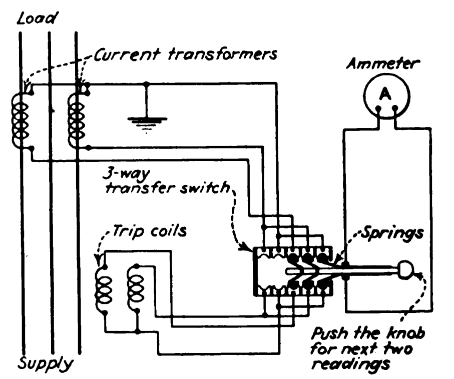
This shows the connections of an ammeter jack for plugging one ammeter into any phase of a three-phase circuit.

obtain a current reading in phase A, insert the plug in the hole containing contacts *1, 2, 11* and *12*. As the plug is pushed in, it connects points *1* and *2*, also *11* and *12* before opening spring clip *1-12*, thereby connecting the ammeter in circuit with the No. 1 current transformer.

To obtain current readings in phases B and C, insert the plug in the hole containing contacts *3, 4, 9* and *10* for a reading in phase B, and in the hole containing contacts *5, 6, 7* and *8* for reading in phase C. With this method of switching the ammeter, the current transformers are short-circuited at all times when the ammeter is not connected for a reading in one of the phases. G. H. WINTERSTEEN.

Cleveland, Ohio.

IN REPLY to A.W.'s question, the accompanying illustration shows the connections which will allow one ammeter to be successively connected to each phase of a three-phase circuit. This method of switching the connections so that the ammeter will indicate the current flow in each phase is practically the same as that used when employing



This shows how one ammeter may be used to indicate the current in each phase of a three-phase circuit.

a three-way ammeter transfer switch. The accompanying diagram indicates the connections which will enable A. W. to secure a reading on the ammeter from any of the three phases, without cutting open the current transformer secondaries, or interfering with the operation of the trip coil.

The General Electric Co. and the Westinghouse Electric Co. can supply the desired transfer switch, and a diagram of the connections necessary. I would advise A. W. to get in touch with a representative of either of these companies in his locality for further information. E. J. ELVISH.

Fort William, Ont., Can.

Using Large Diameter Pulley on Motor

It is practicable to use a 20-in. pulley on a 25-hp., 750-r.p.m. motor? This would result in a peripheral speed of the pulley of 3,926 ft. per min. Would this be good practice? What objections would there be to using this size of pulley on the above motor in view of

the fact that the motor manufacturer does not recommend a pulley of this diameter? Can some reader tell me what types of pulleys I could use or could not use in this case?
Toledo, Ohio. F. H.

THE size of F.H.'s motor pulley is limited by the mechanical clearance and the peripheral speed. The most economical belt speed is from 4,000 to 4,500 f.p.m. and since the speed is 3,926 f.p.m. it is within the range of practical speeds for oak-tanned or chrome leather belting.

For pulleys 12 in. in diameter and over, double belts are desirable because they will be narrower than a single belt for transmitting the same horsepower and would, therefore, reduce the overhang on the motor shaft. Motor manufacturers usually specify the minimum pulley diameter to be used and the maximum allowable width of the belt (or pulley face) to insure that the pressure on the bearings will be within the limits of their design.

When pulleys of large diameter are used they should be as light as possible to reduce the pressure on the bearings. Composition paper pulleys and pressed-steel motor pulleys are satisfactory. Flat-face, crowned, and double-flanged pulleys are used, depending upon the nature of the load and kind of service. Where the belt is shifted from loose to tight pulleys the face of the pulley should be straight. Where the motor is started under load, or heavy loads are imposed at intervals, crowned or double-flanged pulleys are used.

E. H. LAABS.

Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

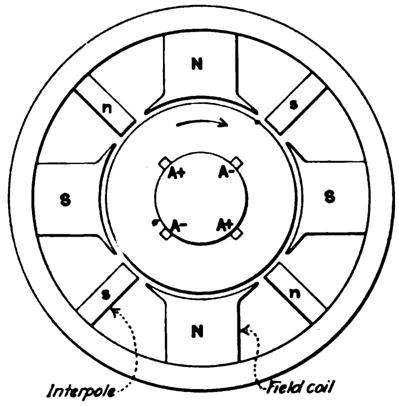
What Is Wrong With This Exciter?

We have a $7\frac{1}{2}$-kw., 125-volt, 60-amp., 1,200-r.p.m. exciter that has always given us considerable trouble. It sparks badly, thereby shortening the life of the brushes and of the commutator. Flats appear on opposite sides of the commutator and the individual bars are badly burned. Channels are burned lengthwise in the center of the bars to a depth of about $\frac{1}{16}$ in. This machine has four-poles, the commutator having 49 bars on the original armature, while the spare armature has 97 bars and 49 coils. Each time we turn the commutator we undercut the mica and test the armature on a transformer or growler. When an armature is replaced in the machine we fit a new set of brushes as supplied by the maker of the machine, and start it with a normal load of 45 amp. It will run well for a day or two with scarcely any sparking. Then it begins to spark and the commutator blackens and heats up. I wish other readers who have had similar experience would tell me how they corrected the trouble.
New Philadelphia, Ohio. R. F. P.

THE trouble encountered by R.F.P. is probably due to one of the following causes. In the first place, the speed of the machine, which is 1,200 r.p.m., is fairly high for a d.c. machine, although there are d.c. machines running at 3,600 r.p.m. and giving good service, but most of these have one or more rings shrunk around the commutator bars. These rings are put on to prevent centrifugal force from throwing the bars out of alignment.

A commutator that is to run at a high speed must receive exceptional care in its assembly. A green commutator must be carefully tightened, baked at the proper temperature, allowed to cool and then tightened up again. After the commutator is assembled and the armature wound, the commutator should be tightened once more, and when the completed armature is removed from the baking oven it is advisable to tighten the commutator studs. The heating and centrifugal force during operation in actual service will sometimes cause the bars to rise unevenly, and sparking will result. The remedy for this trouble is to tighten the studs while the machine is hot, and then turn the commutator.

The interpoles of the machine, if it is so equipped, may be bucking the field proper; that is, connected for the wrong direction of rotation. The proper location of the N and S interpoles, with respect to the N and S poles of the field, for a given rotation, is shown in the accompanying illustration.



This shows the proper polarity of interpoles with respect to field poles for clockwise rotation of armature.

Then again, the polepieces may be too far from, or too close to, the armature, provided there are shims placed under the interpoles. The evidence seems to point to either a defective field structure or to the fact that the machine was originally improperly designed. By consulting the manufacturer, some reliable information can probably be obtained.

Again the bearings may be worn too much, the brushes may not be exactly in the neutral plane or the machine may be vibrating too much. When the machine was new, was the mica undercut in the commutator? All commutators are not milled when new, although most high-speed commutators are milled.

Be sure that no oil reaches the commutator, and that the brush tension is not too heavy; about $1\frac{3}{4}$ lb. should be right. I believe that The National Carbon Co.'s brush No. 255 would be a good brush for this machine.

In turning the commutator, a speed of about 500 ft. per min. is generally satisfactory. The cut should not be too deep because if the cut is deep the tool has a tendency to twist the segments and thereby cut deeper at one edge than at the other, making a great deal of difference on a high-speed machine. The ideal method of truing up a commutator is to grind with a soft-faced revolving stone while the commutator is running at its operating speed. This method will remove any irregularities which the high speed might cause.

The brushes may span too may bars, or the brushes may not be spaced properly. To check the location of the brushes procure a piece of thin paper and pull it tightly around the commutator, marking the lap. Remove the paper and lay off as many divisions as there are brush studs. Replace the paper on the commutator and set the toes of the brushes at these lines. If the brush studs are not parallel to the commutator, bend them until they are. On the other hand, the brush pressure may be too low. If the machine is operated in parallel with other machines, cross-currents may be causing the arcing. If the field poles are unequally spaced around the frame, this is due to faulty manufacture.

GRADY H. EMERSON.

Birmingham, Ala.

IT MIGHT we well for R.F.P. to examine the armature for loose leads or for broken connections at both points of the commutator where the burning is in evidence. A break or open circuit in the coil connected to the burned bars is very probable. Since the exciter has four poles, and is of the series-wound type, it may be that the circuit is open on only one side. Under certain conditions a ground or a flying ground might be the cause of the trouble mentioned.

A test with a growler will be of no use in R. F. P.'s case, but a bar-to-bar or drop test with a sensitive milliammeter may prove helpful.

Ft. Dodge, Iowa. CLAUDE D. MARTIN.

ANSWERING R.F.P., this question presents a peculiar problem, for the trouble does not appear to be in the armatures, although it may seem to be there.

It might be well to check up for the usual armature troubles, particularly brush setting and cleanliness. Since the trouble is manifesting itself in two armatures, it is more than likely to be found in the field winding.

Trouble in the field could be caused by a poor air gap, or a short-circuit in a field coil; or there is a possibility that the frame has blow holes in it, thereby causing a peculiar relationship in the reluctance of the frame.

The air gap can be easily checked and corrected by the use of shims, while a possible short-circuit in the shunt field coils can be checked by impressing a constant voltage on the coils in series, and then measuring the drop, across each.

Blow holes in the frame can be checked by using an X-ray apparatus. The bearings may be causing air-gap trouble, moving up and down due to the weight of the armature; also, a sidewise motion may be caused by the use of a belt drive.

Trouble caused by two bars burning in the commutator is usually associated with armatures that are series wound, in which case the burned spots are oppo-

site and their number is half that of the number of poles in a machine. It would be unusual, however, for both armatures to be open-circuited.

Inequality of brush tension, poor brush spacing, high bars, and a wrong type of brush are often sources of trouble in commutators.

I would, first of all, blame this commutator trouble on the field; therefore, it might be best to work back from the field, and in addition to the possible troubles already mentioned it might pay R. F. P. to look into the design of the exciter in order to note whether the field is weak or enough iron has been used. E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

REFERRING to R. F. P.'s question, I would surmise from the information given that there is an open circuit in the armature. It is very likely that the coil connections are poorly soldered to the bars where the burning occurs. If this trouble has been going on for some time, the insulation will be burned back on the coil leads, necessitating renewal. When the leads are resoldered it will be necessary to raise them from the slots and scrape them very carefully. Also, clean the slots in the commutator bars, as they will be badly corroded by the excessive heating. GORDON S. MAYHEW.

East Angus, Que., Can.

THE question asked by R.F.P. is hard to answer offhand, owing to the many factors that would bring about the condition he describes.

The question fails to state how the generator is driven: that is, belted or direct. Sometimes a belted machine will spark due to improper belt lacing in which case an endless belt is best. In a direct-connected machine worn or loose bearings may cause the trouble, and the other causes which should be investigated are brush pressure, brush spacing, air gap, defective fields, brushes off neutral, brushes not of proper thickness, and wrong grade of brushes. A low brush pressure will cause a poor contact between the brush and the commutator, the result being that the current must travel through a small arc which burns both brush and commutator, causing high mica, and the heat of the arc causes the commutator to heat. If the brush pressures are unequal, the brushes with the most pressure on them will carry the most current. Sparking will result when the brushes are not properly spaced, when the brush studs are not parallel with the commutator bars, and when the brushes span too many bars.

I would also suggest that R. F. P. measure the drop across the field coils. It should be the same for each field, and, if not, the coil having the highest drop is defective.

To check the brush spacing, obtain a piece of wrapping paper that will reach completely around the commutator. Divide the paper into four equal parts, for a four-pole machine, place it around the commutator with the toes of the four sets of brushes at the divisions in the paper. If each set of brushes does not touch the corresponding line, it should be adjusted until it does so.

If the sparking does not stop when the brushes are shifted forward or backward, the fields and air gaps should be examined.

To test for brush thickness, use a low-reading voltmeter, and two ordinary lead pencils, trimming them down flat on one side but do not expose the lead. At the top of the pencils cut a groove down to the lead, attaching a piece of lamp cord to each pencil. Next remove a brush and hold the flat sides of the pencils against the front and back side of the brush-holder, with the leads touching the commutator, and read the voltage. This reading will give the commutation voltage. Shift the brushes until they do not spark. Again read the commutation voltage; if it has decreased, the period of commutation is too short and the brushes are too narrow. If the commutation voltage has increased, the brushes are too wide spanning too many bars, or the neutral field is too small. If making the brushes narrower does not stop the sparking, it may be necessary to widen the neutral field by increasing the distance between adjacent pole tips.

Should the air gaps be unequal, shim up under the poles having the largest gap, or grind off some of the poles having the smallest gap, for in lap- or parallel-wound machines an unequal air gap will cause trouble.

Flat spots may also be caused by a loose commutator, surges of load due to short-circuits, or an unbalanced armature. In that case the armature may be balanced by adding weight to the light side.

I sincerely hope that some of the points herein mentioned will help R. F. P. to solve his problem.

Indianapolis, Ind. M. V. MILLER.

Cause of Fuses Blowing on Transformers

During a recent violent lightning storm, the fuses were blown on one of our 10-kva., 2,300/220-volt, single-phase transformers. This transformer supplies a small, lighting distribution system. The transformer is protected by a pole-type lightning arrester. After the storm was over the fuses were replaced and the transformer operated satisfactorily. I shall appreciate any information that readers can give me on what caused these fuses to blow. I will be very much indebted to any reader who will advise me on this subject.

Wichita, Kan. Z. F. D.

IN ANSWER to the question asked by Z. F. D. we may first consider a transformer fuse as an element designed to melt at a predetermined current value, and intended to act as a protection against abnormal conditions of current. Fuses are generally constructed so that they will carry continuously 110 per cent of their rated current.

A lightning arrester is ordinarily arranged to immediately relieve the system of excess energy due to rises in potential. To do this successfully a path to ground must be provided, the resistance of which decreases as the amount of energy to be discharged increases; that is, as the rise of potential increases. When the surplus energy has been discharged, the resistance of the path to ground must return to its original value immediately; otherwise the effect on the line will be practically a short-circuit, tripping circuit breakers, shutting down the system and thereby defeating the real purpose of the lightning arresters. From the above it is evident that fuses are intended to protect the transformers from abnormal currents and the lightning arresters are intended to protect the transformers from abnormal voltages.

A properly designed transformer, well built of the best materials, will survive a considerable surge of voltage. This surge may not be great enough to cause the lightning arrester to function, but might cause a sufficient increase in current to blow the fuses and yet not damage the transformer windings. The operating records of any light and power company will show that it is not uncommon for lightning storms to cause fuse protecting transformers to blow.

East Kingston, N. H. H. S. RAMSAY.

THE cause of the fuses blowing on Z.F.D.'s transformers may have been due to the line being struck by lightning, a high-voltage wave being induced in the line by induction from an overhead cloud, or by a lightning discharge in the vicinity. It is not likely that the lightning struck the line, but one of the other two conditions may have caused the fuses to blow. Lightning arresters are more protection against a direct stroke of lightning than against an abnormal rise in voltage, or when the rise in line voltage is simply caused by induction, the voltage may not be high enough for the lightning arresters to act, but high enough to blow the fuses. When fuses have been in use for a considerable length of time, their current-carrying capacity is gradually reduced, possibly by corrosion. Fuses are likely to blow, even though the arresters function properly. But, if the arresters do not function properly, fuses would probably not blow quickly enough to protect the line. In Z.F.D.'s case, undoubtedly a high-voltage line current was induced in the line during a thunder shower, the voltage being high enough to cause the line current to blow the fuse but not large enough to do other damage. W. E. WARNER.

Shefford, Bedfordshire, England.

IN ANSWER to Z.F.D.'s question the writer has based his reply wholly on 20 years of experience, in repairing apparatus which lightning had damaged.

Lightning rarely acts twice alike and the troubles that it causes to electrical appartus can be divided into two classes.

The first class represents those troubles caused by lightning striking the primary line feeding the transformers. This is usually disastrous to apparatus that is in the path of the lightning. A lightning arrester may take care of this discharge, and it may not, for the perfect lightning arrester

is yet to be devised. I advocate the use of lightning arresters, but do not expect 100 per cent protection from them for oftentimes damage to transformers is done before the lightning reaches the arrester. There are few pieces of electrical apparatus that receive so little attention as a lightning arrester. Consequently, this neglect frequently is responsible for the arrester not functioning properly on a moderate charge.

The second class of troubles due to lightning are less serious. Even if the transformer is properly fused for carrying its rated load, a small surge caused by lightning, in addition to the normal load on the fuse will cause it to blow, thereby probably saving the transformer serious damage.

It is a natural characteristic of lightning to want to reach the ground, but as air is a good non-conductor, it is only natural to expect that a stroke of lightning coming within striking distance of a nearly perfect conductor to ground, will divert its course to a conductor of less resistance. Before the charge leaves the transformer or conductor on its way to the ground, it has a habit of leaving trouble in its wake.

Lewiston, Maine. A. C. BARKER.

Use of Time Switches

Many times I have felt that clock-operated time switches could be used to advantage in my plant, for instance on baking ovens and yard lights. Before installing these devices, however, I should like to obtain the viewpoint and experience of readers as to where these switches can be used to advantage around the industrial plant. Where are readers now using these switches to advantage and, also, where do they think they could use them if they were to install them at every point at which they would be of value?

Pittsburgh, Pa. K. E.

REGARDING the question by K. E., my experience with time switches has been that they will usually soon repay their initial cost.

When it is necessary to control yard lights that need to be switched on and off at inconvenient times, it is advisable to use time switches, for without them lamps that burn at night are frequently switched on and off at the watchman's convenience.

In the case of electric furnaces, muffles, ovens and the like it often pays to use time switches so as to avoid keeping a man on duty for the specific purpose of switching the current on or off at a certain time.

To obtain satisfactory results, with this type of control device, it is advisable to purchase high-grade switches and then put them under the care of one man who should be held responsible for their proper operation. When the clocks are wound at regular intervals, I have found time switches to be absolutely reliable. W. E. WARNER.

Shefford, Bedfordshire, England.

THE question asked by K. E. should be of especial interest to all large plants, as some of the practical uses of time switches are: controlling industrial process machinery and equipment for pre-determined periods; control of yard, shop, and display lighting; pre-determined control of night and special lighting required by watchman; and automatic control of special alarm systems.

I would suggest that, first of all, K. E. make a careful survey of conditions at his plant to determine whether he wants a definite control over his baking ovens and yard lights, or prefers to maintain manual control in some parts of his plant system. In deciding this point he should balance the cost and convenience of time switches against the cost and convenience, or inconvenience, of the present manual control.

There are many uses for time switches, which make for accurate control, so far as time is concerned, of any equipment to which they can properly be applied.

NATHANIEL W. BLANCHARD.

Inwood, L. I.

IN REPLY to K. E.'s inquiry we have found clock-operated time switches to be most useful time- and money-saving devices, for they can be used to advantage in almost any installation where the time of opening and closing circuits is essential either from the standpoint of economy, or quality of the product being manufactured.

One point I wish to bring out from my experience with time switches is that care is necessary in the selection of a suitable make of switch, which should be made standard throughout the plant. Besides several American-made switches that are very reliable, there is a time switch of a foreign make that is a very fine piece of apparatus, but it is a bit too delicate for the rough service and neglect that a time switch is frequently subjected to. The clock part of these switches is difficult for the average American jeweler or watch-maker to repair.

Time switches of both American and foreign makes are available in practically any voltage.

G. H. WINTERSTEEN.

Cleveland, O.

Power Factor of Transformers Feeding a Resistance Load

We have two 700-kva. single-phase, 25-cycle, 11,000/220-volt Allis Chalmers transformers with an impedance of 58 per cent that are to be connected in open delta to feed a 400-kva. annealing oven which is heated by resistors. All the impedance in each transformer will be removed down to 12 per cent, which is the limit. Will some reader please tell me what the efficiency and power factor of the transformers will be when they are operated in this manner.

Keokuk, Ia. L. M. S.

IN ANSWER to L. M. S.'s question, in order to calculate the efficiency in this case, it would be necessary to know the iron loss and copper loss in these particular transformers. This information can be obtained by test, but could be more easily obtained by consulting the manufacturer who, without question, has these data on record. The full nameplate data, including the serial number, should be sent to the manufacturer. If this information is obtained, the efficiency can be computed as follows: Let W = load, and w = copper loss plus core loss. Then, 100 W $\div$ (W + w) = efficiency.

The efficiency in this case, however, will not be so high as might be desired, due to the fact that the transformers are much larger than required which will increase the iron and copper losses, and that they are connected in open delta. The open delta connection will reduce the capacity of the bank about 9 per cent. The type of load that is to be imposed on these transformers is in the inquirer's favor, as there will be practically no regulation or power factor difficulties caused by this load.

GUY H. WINTERSTEEN.

Cleveland, Ohio.

Repairing Roof Tank

We have a yellow pine roof tank used for storing warm water at our plant. This tank is about 15 ft. in diameter and 45 ft. high. It is made of vertical staves which are held in place by means of circular steel bands, much as is the case with railroad water tanks. Four of these staves were apparently not all hard wood and have rotted away so that they are half gone in places, the remainder of them apparently being hard wood, are sound. The tank cannot conveniently be spared long enough to dismantle and put in new staves; so we would like to know what is the best method of repairing it. The rotting of the wood is on the outside only. We have thought of scraping out all of the rotten wood carefully and then filling in the space with a thick cement grout such as is used in fixing up trees where branches have broken away or decay has taken place. I should like to obtain the advice of readers on the merits of this method and also their suggestion on other methods of making this repair.

New Haven, Conn. H. W. F.

THE repair work involved in the question asked by H. W. F. must be done on the outside of the tank.

I would suggest that H. W. F. carefully scrape out the rotted wood and make a clean surface. Then paint the scraped surface with black asphaltum paint, after which a mixture of tar and portland cement can be used as a filler. When preparing the filler, the tar should be heated and the cement thoroughly mixed with it in a 50-50 proportion. As this mixture hardens quickly, it must be applied without delay.

As soon as the mixture is applied to the recesses and packed in solidly, an iron or wood covering, properly shaped, should be bound over the mixture to make certain that it adheres to the asphaltum binder. After the mixture has set, this covering or support may be removed if desired.

I know from experience that this tar and cement mixture will adhere to wooden side walls and roofs, keeping moisture out, and as the cost of such a job should be small, I can see no reason why it would not solve H. W. F.'s problem.

In the event that this method is used, I should like to hear from H. W. F. concerning the success of the repair job.

NATHANIEL W. BLANCHARD.

Inwood, L. I.

Correction

IN THE answer given by Claude D. Martin to W.T.'s question, on page 138 of the March issue, an error was made in the third line from the end of the first paragraph. This line reads "amperage is determined by dividing," whereas it should have read, "amperage is determined by *multiplying*."

Electrical Service

AROUND THE WORKS

Illuminating Dark Spots by Special Fixture Units

WHEN properly placed, small lighting units are often economical and efficient, even though the tendency of modern industrial lighting is toward large units which are usually located some distance from the working plane. In general, large lighting units are highly satisfactory, but one does find an occasional machine, or a cramped corner which, to be properly lighted, requires some special form of fixture.

There are on the market a number of excellent adjustable fixtures. Some of these fit the requirements of certain machines; some are so built that they are applicable in the strangest of positions. If one of these patented fixtures meets the conditions of the problem in hand, then it is easily solved. However, there are two prominent objections to such fixtures: First, the expense of outfitting a large number of similar machines may prove to be so large that the cost will prohibit their installation. On the other hand, the number of flexible joints may make the fixture so bulky as to be objectionable.

It requires only a little thought and very little labor to build fittings that will fit the job, and once in place, the economy of current consumption and the increased efficiency of the operator will usually more than compensate for the small expense of construction.

The accompanying illustration is typical of what can be inexpensively accomplished with small lighting units. For example, with the eyeletting machine, shown at *A*, it was found necessary to throw the light on the platen from the right side, and to protect the operator's eyes from the glare of the light.

The sole-cutting machine shown at *B*, is a particularly good instance of the need for special lighting. The stock to be cut passes over the platen, the pattern being held by the cast arms just above the platen. In order that the operator may watch the course of the knife, light must be thrown between the platen and the pattern frame so that the sheet of stock will be well lighted. Also, the lamp itself must be well out of the way to allow free passage of the stock from the left-hand table to the one on the right. The fixture shown complies with all these conditions. In this case it is a twin fixture, one light being fastened at each side of the machine, the pipes meeting at a common feed pipe in the back of the machine.

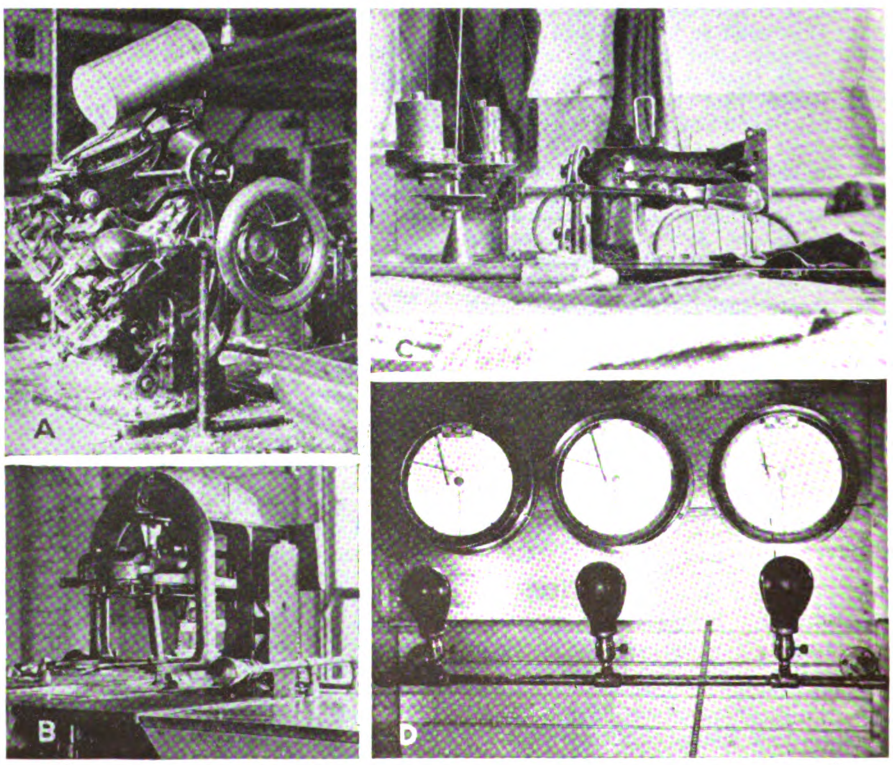
For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

The form of fixture shown at *C* is quite simple. The difficulty of lighting this sewing machine was that the fixture must not be installed rigidly, because it is necessary to tilt the machine back to make adjustments. To meet this condition a ⅜-in. drop L condulet was reamed clean of its threads and screwed to the bench, as a footing to support the fixture. The upright of the fixture was ground with a slight taper at its lower end, and then simply given a twist fit into the reamed footing. When the operator wishes to tilt back the machine, it is merely necessary to pull the fixture out of the footing and place it out of the way.

The recording thermometers, shown at *D*, were originally lighted from above. Since the recording arms are pivoted from the tops of the instruments, this first form of lighting threw a shadow down from the point of the pen. These pen points are used as indicators, and by means of control valves they are made to trace over a predetermined curve on the chart. With the shadow at the point of the pen it was really difficult for the operator to follow this curve closely, simply because he could not accurately note the true position of the indicator. To overcome the dark spot, the lights were installed so that the instruments are illuminated from below, the shadows from the pen points being thrown upward and away from the point of observation. After this change was completed, a marked improvement in the curves immediately resulted. Other machines having dark spots may also be similarly illuminated.

JAMES P. MARSHALL.

Electrical Engineer,
Bourn Rubber Mfg. Co.,
Providence, R. I.



This shows how dark spots were illuminated on the platen of an eyeletting machine at *A*, on a sole-cutting machine at *B*, on a sewing machine at *C*, and on recording thermometers at *D*.

Heavy Oil on Rotor Cause of Unusual Motor Trouble

THE sudden change in weather one night from warm to chilly was the cause of an uncommon trouble on a 15-hp., three-phase, 220-volt motor driving the lineshaft in a small foundry. This motor started star and ran delta-connected—that is, it had a star-delta connection on the outside of the stator for starting purposes. This ar-

rangement gives approximately the same result as an auto starter connected on the 65 per cent tap, which connection results in a very low starting torque.

When it was found that the motor would not start, the belt was removed from the motor pulley. The owner of the place could not turn the rotor; so he took the endbells off the motor, and as they turned freely, he was certain that the bearings were not stuck. The motor bearings were fitted reasonably tight, so he was at a loss to know what was causing the trouble.

When I arrived, I asked the owner how his motor acted when it had run last and what had been done to remedy the trouble. He said it had run until 9 o'clock the night before; then he had shut it down himself. There was plenty of oil in the bearings and they were all right as far as he knew. I closed the starting side of the switch, but it only caused the motor to hum. Closing the running side of the switch gave the same result.

The fuses were found to be in good condition; so I shut down all the other motors on that line and tested it with a 220-volt test light. The light burned brightly on all phases. My reason for shutting down the other motors was to prevent current being fed back in the blown fuse line by any other motor, for in this case the test light would burn on all phases, even though a fuse were blown. The motor bearings were tested again and found to be OK, so the end frames were removed entirely. Two helpers had considerable difficulty in trying to remove the rotor, but after examining the rotor and stator to see if something had wedged between them, more force was applied to the rotor and it came out.

It was found that the surfaces of the stator and rotor were covered with a stiff paste something on the order of dough. They were given a good gasoline bath, after which the rotor was assembled and the motor ran perfectly.

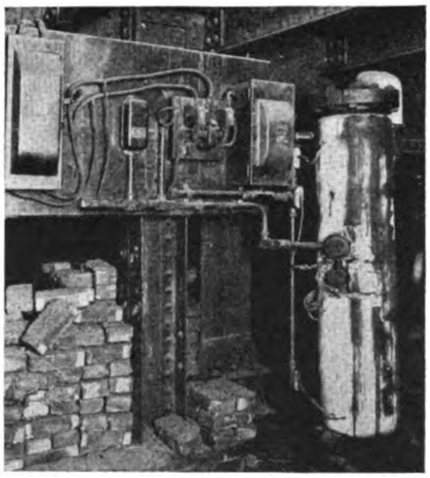
A little study showed that an excess amount of oil that had been poured into the oil wells had overflowed onto the rotor. This oil, mixed with the foundry dust, made such a heavy paste that when the weather turned suddenly cool, it prevented the rotor from turning.

GRADY H. EMERSON.

Method of Preheating Fuel Oil Electrically

THE efficient combustion of fuel oil depends, to a certain extent, upon maintaining a constant fluidity of the oil at the burners, and the fluidity, in turn, depends upon the temperature of the oil. According to C. J. Carrigan, of the Phoenix Rolls Corp., Pittsburgh, Pa., two electrically-heated oil heaters are used for preheating the fuel oil used in their open hearth furnaces.

Each of these heaters consists of a cylindrical tank, 10 in. in diameter by 96 in. high, and 32 Westinghouse space heaters, arranged around the tank, heat the oil. The oil temperature is automatically controlled by means of a bimetallic thermostat mounted on the side of the oil tank, through a motor-operated snap switch and a contactor. The oil, which is circulated by a motor-driven pump, enters the heater at the bottom and leaves from the top. The capacity of each heater is sufficient to heat 100 gal. of oil per hr. to 180-210 deg. F.



The oil is heated by passing it through these tanks which are fitted with space heaters, mounted on the outside.

A constant temperature is maintained by means of a thermostat which serves to open and close the heating circuit through a motor driven switch and contactor.

One of the chief features of this method is that the control apparatus keeps the temperature of the oil at the desired point without any attention on the part of the operators. By using these preheaters more efficient combustion in the open hearth furnaces is obtained, with a resultant saving in the cost of fuel.

Causes and Remedies for Some D. C. Motor Troubles

MOST d. c. motor troubles center around commutation and trouble is generally signalized by heavy sparking at the brushes.

Usually a small amount of sparking does not harm the commutator bars, but if it should, the cause of the sparking should be removed at the earliest opportunity. Small, noiseless, whitish-colored sparks on the edge of the brush are harmless. Sparking at irregular intervals, accompanied by a green flame and a hissing sound, is due to small particles of copper that have been disintegrated by continuous overheating, and will in a very short time cut a furrow around the commutator, and bits will adhere to the brushes. While an overload may in some cases cause excessive sparking, this is not usually the primary cause. Most reliable makes of motors are guaranteed for a 50 per cent, and with some makes 100 per cent, momentary overload. However, to allow an appreciable overload to remain, is a clear case of abuse, and the motor will naturally overheat.

Should there be sufficient overload on the motors to cause excessive sparking, some relief may be obtained by shifting the brushes, but the overload should be removed as soon as possible.

When the motor is not overloaded, we may look for the cause of sparking in the brushes. Shifting the brushes backward and forward may diminish sparking, or the cause may be due to incorrect spacing of the brushes. In order to determine the correct spacing of the brushes, apply the following rule: Total number of commutator bars divided by number of poles equals the number of commutator bars allowable between the edges of two adjacent brushes. When a good brush contact is being made, the commutator will assume a smooth, glassy surface with a rich chocolate color and the contact surface of the brush will be smooth.

In the event that the composition of the brushes is too soft or too hard, this fact will show itself in the surface of both the commutator and the brushes. If the surface of the brushes and commutator appears rough, and ploughed up, with specks of metal attached to the brushes, the latter may be immersed in a bath of hot petroleum jelly and boiled for a time, after which they should be thoroughly cleaned and dried. Fine sandpaper should be drawn between the commutator and each brush, with the rough side of the paper against the brush, to reseat it.

The commutator surface must be kept clean and glossy at all times. If it becomes roughened up as mentioned above this can be remedied by the use of a commutator stone or sandpaper held against the commutator with a wooden form. Care should be taken that all dust and abrasive material is removed before putting the motor into service again. Grease should be kept away from the commutator. Where this is hard to avoid, as in oil well drilling and pumping, a totally-enclosed motor is often used, which obviates this trouble.

Should the commutator become eccentric, nothing can be done for it while in service; it will be necessary to put the armature in a lathe and true up the commutator with a turning tool.

Other causes of sparking, such as grounds, open circuits and short-circuits, may be detected by test instruments.

Overheating may be due to several conditions, among which are poor bearing surfaces that cause excessive friction. Faulty lubrication is often the cause of this condition. The oil used in motors must be of the best quality, and adapted to the service conditions. Sometimes in a small plant, an oiler will use, regardless of its condition, old oil that may have been taken from the overflow of other machines. Where there are a large number of motors, it is economy to have a reputable oil company send in an expert to recommend the proper oil to use on each motor. Although this means that the oil company naturally expects that its products will be used, it has been my experience that this procedure will save trouble. This method of handling lubrication problems should likewise be applied to all mechanical equipment.

Shafting that is out of line, or tight belts will also cause heating, and the remedies are obvious.

All connections should be periodically tested out and tightened if necessary,

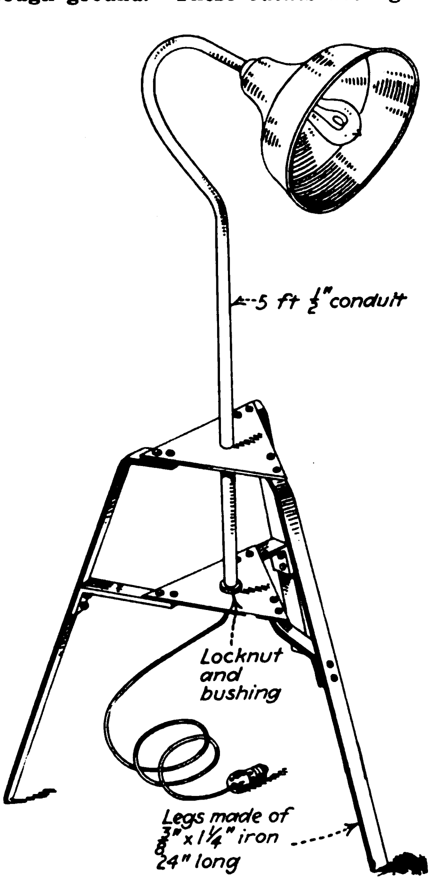
especially in the case of motors that are mounted on slide rails for adjustment, where any looseness will set up a vibration. Should a motor by any chance be thoroughly wetted by rain, or through the bursting of a pipe, or other mishap, no attempt should be made to run it, on the chance that it will dry out. It should be taken down and thoroughly dried out in the oven first. This may appear to be unnecessary, but it is cheaper than having coils burn out. M. C. COCKSHOTT.
Hollywood, Calif.

Inexpensive Portable Floodlight for Temporary Use

IT SUDDENLY became necessary to construct some sort of a temporary lighting system at the plant where the writer was employed in order to rush night work on an excavation job. Floodlights were out of the question, as the night work would not continue very long. To meet the emergency, the plant electrician made up the lamp reflector and stand for holding it, shown in the accompanying illustration.

The total cost of each stand was $4.18, as shown in the accompanying itemized cost list of the various parts needed.

The two triangular-shaped pieces of iron used in the stand are ⅜ in. in thickness and were sheared from a piece of scrap iron. A 250-watt lamp is supplied with each stand, thus completing the lighting unit. Due to three legs being used rather than four, the lamp stands firmly, even though placed on rough ground. These outfits are light and easily moved from place to place, and yet they are strong and rugged enough for almost any purpose.



This shows the construction of a portable floodlight stand for use on a temporary job.

Cost of Floodlight Parts

Item	Cost
Reflector	$1.60
Socket	.30
Locknut and bushing	.06
5 ft. ½-in. conduit	.35
6 ⅜-in. x 1-in. bolts	.18
6 ¼-in. x 1-in. stove bolts	.12
6 ft. ⅜-in. x 1¼-in. flat iron	.42
3 short pieces of strap iron	.05
12 ft. No. 14 wire and plug	.20
Labor	.90
Total Cost	$4.18

Electrician, CHAS. A. PETERSON.
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Simple Commutation Troubles Often Caused by Neglect

AS ONE example of how an apparently easily detected commutation trouble will often mislead the operator into believing that his difficulty is caused by a defect not at the commutator, an experience that I had while calling on an operator friend is interesting. He looked for winding troubles as a cause of poor commutation, when the trouble actually was caused by the entire set of brush springs, which had been in use so long that their elasticity had nearly disappeared.

This permanent set in brush springs may also be caused by giving the brush rigging so little attention that the pigtails cease to carry current, this duty being transferred to the brush springs which become heated occasionally when there is a heavy load on the machine. This heating draws the temper of the springs. If the spring tension behind the brush does not act quickly and constantly in maintaining the brush pressure on the fast-moving commutator bars, good commutation cannot be expected, of course.

I have observed many generators where the brushes underneath the commutator have had little attention because they were hard to get at, although thorough cleanliness of the parts that comprise the brush-holder is essential. As an aid in cleaning commutators several non-inflammable liquids are on the market that have all the grease-absorbing characteristics of benzine but none of the fire hazards. These liquids may be used with a stiff, clean paint brush to wash the dirt and accumulated grease from the brush-holders, thus maintaining a free movement of the brush-holder parts so that everything will be in readiness to handle the peak demands on the machine.

Collector rings usually are so free from troubles that the glaze on them is frequently unnoticed, but I have observed a.c. slip-ring motors connected to intermittent start-and-stop apparatus, like elevators, where the removal of the glaze from the rings reduced the time of acceleration 40 per cent, thus saving considerable power and adding to the efficiency of the apparatus as a whole. It pays to watch commutators and slip rings carefully.
Manager, WILLIAM L. WEBER.
Acme Abrasive Co.,
Chicago, Ill.

Comments on "Planning Distribution System"

THE article by Marin Phillips in the January issue of INDUSTRIAL ENGINEER was very interesting. However, I should like to say, relative to his statements on making splices and taps in junction boxes, that I prefer the use of Dossert, Frankel or similar cable connectors.

Although it is perfectly true that hand-made splices, taps, and pigtails have been in use for many years, there is no question that the types of cable connectors mentioned above save a great deal of time, especially when changes are to be made in the wiring system of a plant. In an industrial plant that is growing rapidly there are usually frequent changes in, or additions to, the electrical equipment. If this point is kept in mind when an installation is made, future changes will be much easier to handle.

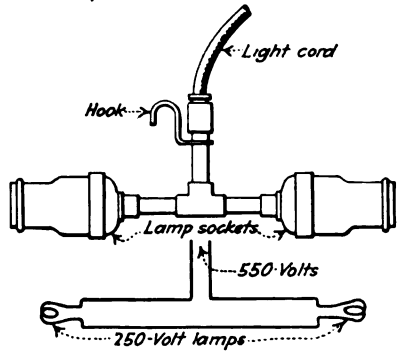
When this type of connector was introduced I was rather skeptical about such devices giving satisfactory service, but have now used them for several years without ever having any trouble due to heating of the joints.

Mr. Phillips's practice of using lugs in making splices is good. I know from personal experience that this method gives very good results and that such joints are much better and easier to handle than a soldered splice when changes are to be made.
Electrician, CHAS. A. PETERSON.
Fairbanks Exploration Co.,
Fairbanks, Alaska.

How to Make Handy 550-Volt Test Lamp Holder

THE test lamp holder shown in the accompanying sketch will, perhaps, prove to be a welcome departure from the usual cumbersome lampbank. Its construction is simple, the required materials consisting of three ⅜-in. short nipples, one ⅜-in. tee, one ⅜-in. coupling, one ⅜-in. composition socket bushing, and two sockets, assembled as shown in the accompanying illustration. A hook made of strong wire and fastened to the nipple just below the coupling will be found useful, since it will allow the user to hook the tester onto his belt, thus leaving both hands free for other work.

The 250-volt test lamps used in this holder should be connected in series, as shown.
Providence, R. I. JAMES P. MARSHALL.



Here is a test lamp holder that is inexpensive and easy to carry around.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Supporting Double Row of Shafts from Building Column

RECENTLY in a visit to an industrial plant, the writer had the good fortune to observe the erection of two lines of shafting in a steel building where the construction presented unusual difficulties. This was a steel and glass, single-story building that was being changed from dead storage purposes to a machine room.

The building had a row of columns of Bethlehem H-beams down the center and a clear floor space of 60 ft. on each side. The columns were joined about 16 ft. from the floor by the 12-in., 31-lb. steel I-beams *A* and *B*, shown in the accompanying sketch. These beams were riveted to short sections of angles or brackets which, in turn, were riveted to the columns. This construction was amply strong enough for its original purpose and also was able to carry a reasonable amount of additional weight.

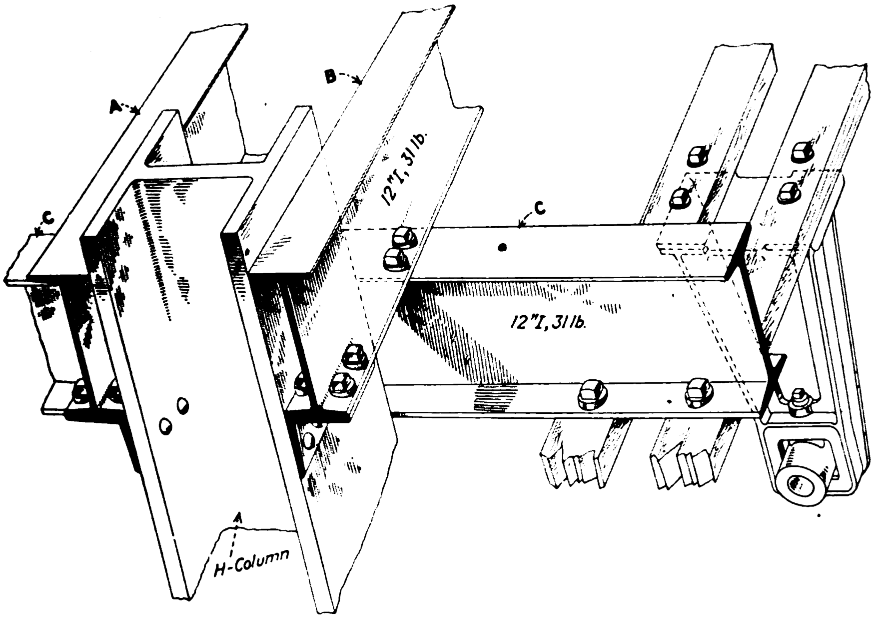
The plan used in fitting up the building for production was to arrange the machinery in a double row down the center of the building, with a row of machinery on each side of the column. The machines were thus compactly placed and close to the only feasible location for suspending an overhead structure to support the lineshafts. This left a large part of the floor space in the two bays available for other work. The layout included a single length of 300 ft. of lineshaft and an equal length spaced off into several smaller group drives for some machines.

The method of suspension used was rugged and simple. Its basic unit was a short length of 12-in., 31-lb. I-beam, *C*, bolted to the pair of longitudinal beams *A* and *B*. This short beam *C* was placed against the side of the H-column and bolted to each side of the lower flanges of *A* and *B*. The beam *C* was thus suspended by the bolts. It would have been better practice to rest them on top of the longitudinal beams and have the bolts serve only for holding the beams in position, but other structural features of the building prevented this. Also, there would have been some disadvantage in this case from raising the shafting higher.

Instead of bolting the hangers to the stub beams *C*, as might have been done, a pair of timbers or stringers was run the full length of the building on each side of the H-column and bolted to *C*. The hangers were then bolted to the stringers. Some of the advantages of this plan included reduced likelihood of breaking the cast-iron hangers if rough hangers were bolted to the steel flanges of the I-beams, the ability to space the hangers where desired instead of mounting on the column centers, easier erection, and so on.

Using cantilever support for a double row of lineshafting.

When a building is not planned for production it is frequently necessary to use ingenious methods for supporting lineshafting. Here short, cross I-beams *C* are fastened to the pair of longitudinal I-beams *A* and *B*, and a row of shafts suspended from each end. These shafts serve two rows of machinery. The motors are mounted on wooden sleepers supported on the top of *A* and *B*. Another row of shaft hangers is attached to the cross beams *C* at the left end, although they are not shown in this drawing.



The driving motors were placed on top of the steel I-beams *A* and *B* on wooden sleepers positioned to suit the drives.

This method of support has much to commend it. The single rows of shafts on each side of the column form a balanced cantilever suspension that adds but little stress to the building structure. There is nothing in the construction which would be in the way of cranes, should these be installed later. This construction is not expensive, in that there are few holes to drill in the permanent structure. Also, the layout is economical of light and floor space.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Using Oxyacetylene Torch When Relining Bearings

NOT only is the oxyacetylene torch useful for welding and cutting around the industrial plant, but it can also he used as a source of heat for removing babbitt from old bearings and also for babbitting according to the Smith Welding Equipment Corporation, Minneapolis, Minn. The flame is easily adjusted to the proper temperature and saves much time in melting out the old metal and burning off the grease for cleaning the bearing mold. The tip used need not be large and should be kept in motion by playing over the old metal until it is all melted out, but care should be taken not to burn the metal. Playing the torch flame over the mold will burn out the oil or grease and any other foreign matter, and dry up the bearing so that a wire brush will clean it perfectly.

Preheating the bearing mold for a new lining is a most important part of the work, because the babbitt will not adhere to cold metal. The difficulty of heating and then placing the bearing in place for the pour is well known to anyone having this work to do. Using the torch simplifies the work to a great extent, because with it the mandrel or shaft can be warmed up and the bearing molds heated while in place. The melting pot should then be heated, and

after adding metal, the heat for melting is supplied by playing the torch flame on the bottom of the pot. Any desired temperature of bearing mold and pot metal can be obtained and a perfect pour made.

Often a worn or scored bearing can be repaired with the torch. The lining must first be washed with lye water and all traces of oil removed. By using a filler rod of babbitt metal, the scores are built up and the bearing can then be scraped in. Building up worn brasses and babbitt metal bearings requires skillful manipulation of the torch. Spots are built up and allowed to solidify; the welder works each spot toward the center of the bearing and finally completes the welding work at this point.

Making a weld near a bearing will often necessitate repouring the bearing unless some precaution is taken to prevent the soft metal from melting. Frequently repouring can be avoided by placing a piece of pipe, approximately the size of the shaft, in the bearing and circulating water through it.

The valve gear on feed pumps wears out constantly and probably gives more trouble from lost motion than any other part of the plant equipment. The easiest and quickest method of repairing is to fill up the valve rod heads with steel or bronze by using the torch and drill out for the pin.

Worn bearings in the crosshead stand can be repaired best by welding in cast iron to a depth of 1 in. and drilling out for the rocker shaft. It will be necessary, in order to fill up the old bearing space, to back it up with asbestos or carbon paste.

In one case, the partition between the valve chambers on a feed pump had become so pitted that the gasket would not hold, although the remainder of the pump was in excellent shape. This part was built up with bronze, which was dressed down by hand, and has been in use two years without replacing a gasket.

Some Recent Developments in High-Speed Chain Drives

IN A comprehensive paper, carrying the above title and covering the application of chain drives, which was read at the recent meeting of the American Gear Manufacturers Association at Briarcliff Lodge, Briarcliff Manor, N. Y., George M. Bartlett, Chief Engineer, Diamond Chain and Manufacturing Co., Indianapolis, Ind., brought out the following interesting points on chain drives. The technical discussion and formulas are omitted in this summary.

"The behavior of a chain drive of the so-called silent, inverted-tooth, or roller type is affected by such primary conditions as sprocket speed, horsepower, center distance, and number of teeth, and such secondary conditions as chain velocity, pull, length, angle of bend of links, weight of links, and projected area of rollers. Other influences are centrifugal force, friction, inertia and impact.

"To illustrate some of these effects, let us assume that a sprocket has its tooth number changed from 12 to 24, the revolutions remaining the same. The pull then becomes only half as great, if transmitting the same power, and each link turns an angle half as great, although there are twice as many bends per minute. The chain length increases, considering that the center distance remains constant, and the wear is thus divided among more links; in fact, it is only four-elevenths as great in the latter case as in the former, and the life of the chain is multiplied by 2¾.

"The wear on the chain pins has been found to be proportional to the angle of bend times the bends per minute times the chain pull, divided by the number of links in the chain. The life of the chain is, therefore, proportional to the product of the number of teeth multiplied by the chain length in inches.

"It might appear that when the chain velocity is doubled, assuming constant r.p.m., the rollers must approach the sprocket with twice the velocity. However, the impact between the rollers and the sprocket teeth does not take place in a direction parallel to the chain travel but perpendicular to it. Hence, the velocity of impact is proportional to the angular velocity of the approaching link about its pin, which is in turn equal to the angular velocity of the sprocket itself and is, therefore, independent of the number of teeth or of the chain velocity.

"Under high lineal velocities there are three factors that may affect the correct action between the chain links and the sprocket teeth: inertia of the individual links, viscosity of the lubricant surrounding the pins, and centrifugal force. Because of the first two factors, the chain appears to resist the act of unwrapping, but this condition seems to have no ill effect upon the drive even at high chain velocity. The sprocket teeth have no part in this phenomenon, since the same thing occurs when the chain is simply wrapped around a smooth pulley.

"We may say that centrifugal force is probably the only factor that produces a measurable effect on the action of the chain at high lineal velocities. A small amount of slack in the chain is usually desirable, but where the velocity is high centrifugal force affects the correct action near the point where the pull is low and it is necessary to take up most of the slack in order to avoid the tendency of the rollers to 'top the teeth.'

"While the lineal velocity of the chain has little effect upon its operation, the rotating speed of the sprocket is a determining factor, since it directly affects the impact between the chain and the sprocket. The velocity of impact is independent of the number of teeth, or of the angle of bend of the link, or of the chain velocity. Instead it depends directly upon the r.p.m. of the sprocket and the pitch of the chain. The energy of impact between the roller and the sprocket is proportional to the weight of the chain link and to the square of the velocity of impact, while the destructive action between a roller and sprocket is proportional to the energy of impact divided by the projected area of the roller. The velocity of impact, on the other hand, is proportional to the r.p.m. of the sprocket and also to the chain pitch.

"By a study of the mathematical analysis of this problem, it is evident that in order to attain high sprocket speeds the pitch must be kept short, the weight of the chain low, and the roller area high. When the proper formula is applied to the standard series of roller chains, the maximum speeds shown in the accompanying table are obtained. The sprocket speeds shown in the third column are the highest advisable speeds for any type of chain, whether roller or tooth type, and in actual practice the speeds are usually not more than 75 per cent of those given in the table.

"In order to use a short-pitch chain for high speeds and at the same time transmit an appreciable load, it is necessary to provide a special type of roller chain designed for light weight, short pitch and large roller area. To do this it is only necessary to build up standard roller chains of short pitch in double, triple and quadruple widths, and to give proper attention to accuracy and precision of manufacture of the chain parts, including uniform heat-treatment of the bearing surfaces.

"Obviously, precision in this design is important because of the multiple width. With such chains it is possible to transmit two, three and four times as much power at a given speed as was formerly the case, and it is also possible to transmit a given amount of power at three or four times the speed in r.p.m. as is possible with single-width standard chains. Such chains operate much more quietly than do chains of single width. Some chain drives are noisy because of the acoustic conditions connected with the installations and some parts of the mounting may act as resonators."

Maximum Sprocket Speeds for Roller Chain

Chain No.	Pitch, In.	Max. R.P.M.	Average Horsepower Single	Double	Triple
30W	⅜	3,600	1.5	3	4.5
40W	½	2,600	2¼	4.5	6.75
50W	⅝	1,900	3½	7	10
60W	¾	1,500	5	10	15
80W	1	940	0	18	27
100W	1¼	645	13	26	39
120W	1½	520	19.5	39	58
140W	1¾	370	23.25	36.5	69.5
160W	2	325	31.5	63	94.5

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Method of Cutting Mica Segments for Commutators

THE article by C. B. Keck, entitled "Method of Cutting Mica Segments to Save Time and Waste of Material," on page 341 of the July issue of INDUSTRIAL ENGINEER, called to mind the procedure followed in a certain large repair shop.

The sheet mica is first cut into strips the full length of the sheet, the width of the strips being equal to the length of the commutator bars. Square edges are essential so care must be taken in cutting the strips. After cutting into strips on a strawboard cutter, the mica segments are cut off.

The dotted lines in Fig. 1 *II* indicate the positions that the commutator bars would assume if they were laid upon the uncut mica strip.

By drawing a line through the points, *X* and *Y*, in diagram *I* of Fig. 1, the waste material space, as shown in Mr. Keck's article, will be cut by a diagonal line. The point *X* is located by measuring $\frac{1}{16}$ in. above the front top corner of the commutator bar neck, and *Y* is located by measuring $\frac{1}{16}$ in. above the top of the front end of the bar.

Cutting out a mica blank for a segment requires only two operations of the cutter, the first cut being made along line *X-Y* and the second cut on line *E-F*.

The greatest amount of waste occurs with the high neck type of bars. Assume that Fig. 1 *I* shows a high neck bar for which we are to cut new mica strips. This bar is 7 in. long by 2¾ in. high, the neck being 1⅛ in. high by ⅞ in. wide. The height of the bar in the front and the rear is 2¾ in. and 3⅞ in. respectively. These dimensions can be taken directly from the bar.

Fig. 2 *I* shows the method of setting the straight edge and protractor arm on the table top of the strawboard cutter. First. measure back along the straight edge from the edge of the stationary knife a distance *A* which is equal to the dimension *A* in *I* of Fig. 1, thus determining the position of point *D*, Fig. 2 *II*. From point *D* measure along the protractor arm a distance *L* which is equal to the distance *B* in Fig. 1 *I*. A paper templet can be used in place of the commutator bar although the best method, after one gets used to it, is to place the commutator bar on the table top, arranging the protractor arm so that the correct angle and distances *B* and *A* are obtained, as in Fig. 2 *I*.

Fig. 2 *II* shows how the strips are fed into the cutter to make the first cut. The front edge of the strip is pushed flush against the protractor arm and one corner to point *D*, which is the intersecting point of the straightedge and the protractor arm. The shaded portion *C* shows the location and the shape of the segment that the first cut makes.

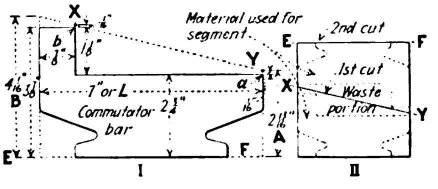


Fig. 1—This shows how mica segments can be cut with a minimum of waste.

I represents a typical commutator bar which serves as a pattern for the segments. The mica is first cut into strips. These are then cut, as shown in *II*, into pieces each of which will make one segment.

To make the second cut the mica strip is turned over 180 deg. then the mica strip corners *G* and *H* in *II* of Fig. 2, assume the positions indicated in *III*, Fig. 2. In this diagram *C* indicates the portion of mica strip obtained from the second cut.

Notice that with the first cut the end of the mica strip is held against the protractor arm and the cutter makes a diagonal cut through the strip, but when the strip is flopped over for the second cut, the diagonal end is against the protractor arm and the cutter makes a straight line cut across the strip, as shown in Fig. 2 *III*.

To make the third cut, the strip is fed into the cutter as shown in *II* of Fig. 2. The fourth cut is made in the same manner as was the second, and so on until all the strip has been used.

Where a bandsaw is available, a simple and quick method of procedure is to cut the mica sheets into strips as previously described, and then shellac the bars to the long mica strips. Place the bars as shown in Fig. 1 *II*. After the shellac has set, the long strips may be cut at *X-Y* and *E-F* alternately. A saw should be used which has very little set. Copper saws are sometimes used for this work.

After cutting the strips, the mica around the bars, including the V's, can be cut away. The workman must be cautioned not to cut within $\frac{1}{32}$ in. from the copper bar. After placing the bar and mica in a vise, this $\frac{1}{32}$-in. strip can be removed by using a knife file.

A. C. ROE.

Renewal Parts Engineering Dept.,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

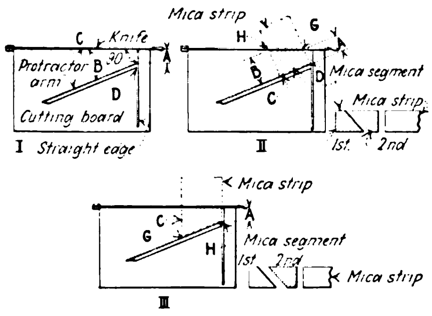


Fig. 2—How the mica strips are placed for cutting.

The protractor arm is adjusted as shown in *I*, prior to making the first cut. The position of the strip for the first cut is shown in *II*. For the second cut the position of the strip is reversed, as indicated in *III*.

Factors in Rewinding Motors for Different Frequencies

WHEN changing an induction motor to operate at a different frequency, several points should be considered. Since frequency has a direct effect upon the speed of an a.c. motor, it is necessary to make sure that the motor speed will remain within safe limits after a change in frequency has been made.

The cause of this change in speed, with the voltage remaining the same, is due to the change in the velocity of the rotating magnetic field. The rotating magnetic field varies in direct ratio and in the same direction as the change in frequency. With a constant magnetic flux, the electromotive force generated depends upon the rate at which the wires cut through the magnetic field. Therefore, by changing the frequency, the emf. generated is changed in the same ratio.

If the flux density and torque are to remain the same for the new frequency, the applied voltage must be changed in the same ratio as the change in frequency. The new values for the speed, voltage and horsepower ratings, can be expressed as follows: New speed = original speed × (new frequency ÷ original frequency); new voltage = original voltage × (new frequency ÷ original frequency); new horsepower = original horsepower × (new frequency ÷ original frequency).

If a motor is operated, without reconnection, on a higher frequency than that for which it was designed, the voltage, speed, horsepower and heating effect must be given consideration.

It has already been shown that, if the operating characteristics of a motor are to remain the same after a

change in frequency, the applied voltage must be changed in the same ratio. Thus, if a 30-cycle, 220-volt, 15-hp. motor is operated on a 60-cycle circuit, the new voltage should be: $220 \times (60 \div 30) = 440$ volts. The new horsepower rating will then be $15 \times (60 \div 30) = 30$ hp. If the connections to the load were changed so that the speed of the driven machine remains the same, the motor would operate at, $15 \div 30 = 0.50$, or 50 per cent of full-load capacity, and besides causing a decrease in the power factor, the efficiency of the motor would also be decreased.

An increase in frequency not only causes an increase in the hysteresis and eddy current losses, but it tends to increase the temperature of the machine. Although the increase in speed will improve the ventilation of the motor, it is a question whether or not the increased heating due to the hysteresis and eddy current losses in the iron will be balanced by the increase in ventilation, for much depends upon the design of the motor.

The peripheral speed of the rotor should not exceed 7,000 ft. per min. (without consulting the manufacturer). The peripheral speed is computed by multiplying the circumference in feet by the r.p.m.

If a motor that is designed to operate on a 25-cycle circuit is operated on a 60-cycle circuit, its speed will be increased $60 \div 25 = 2.4$ times the original speed. The rotor will have to be checked to see if the end rings have the proper resistance in order to give the desired starting torque without taking an excessive starting current.

When the frequency is raised, the resistance of the short-circuiting rings at the end of the rotor windings must be increased so as to maintain the same relative value of starting torque to full-load torque and, conversely, when the frequency is decreased, the resistance can be reduced, which cuts down the rotor copper loss and the heating.

Indianapolis, Ind. M. V. MILLER.

Opening Armature Slots Raised Speed of D.C. Motor

IN A case that I know of the slots in the core of a direct-current motor armature were opened up to permit form-wound coils to be installed in place of an old hand winding. When the job was finished, the motor running speed was 120 per cent above its normal running speed before rewinding.

To reduce the speed to normal, it was considered advisable to fit thin iron shims on the field pole shoes. This shimming up caused a stronger magnetic field and a reduced armature speed. The speed of the motor in this case might also have been reduced by winding a few more turns on the field coils. These extra turns would also cause a stronger field and a lower armature speed; or the field coils might have been supplied with current at normal voltage while the armature and the series winding were supplied with current through a resistance. This latter method would, however, be inefficient and wasteful.

W. E. WARNER.
Shefford, Bedfordshire, England.

Some Handy Winding Tools That Are Easy to Make

SEVERAL tools which I have found very handy for the armature winder are shown in the accompanying illustration. Even though many armature winders use tools similar to the ones that will be described, I have seldom noticed such tools advertised for sale. Tools of the sizes shown are intended to be used on medium-sized winding jobs, but, of course, the winder can easily have larger or smaller tools made in a machine shop, so that they will fit the average job that he customarily works on.

The drift shown at *A* in the accompanying illustration should be made preferably from horn fiber. This coil drift is used to shape the coils after they are in the slot, especially when the coils are difficult to get at.

At *B* a cell paper cutter is shown, which can be made from a 6-in. file. After taking the temper out of the file, and grinding off the teeth on an emery wheel, cut a V-shaped slot about ⅞ in. long in the end.

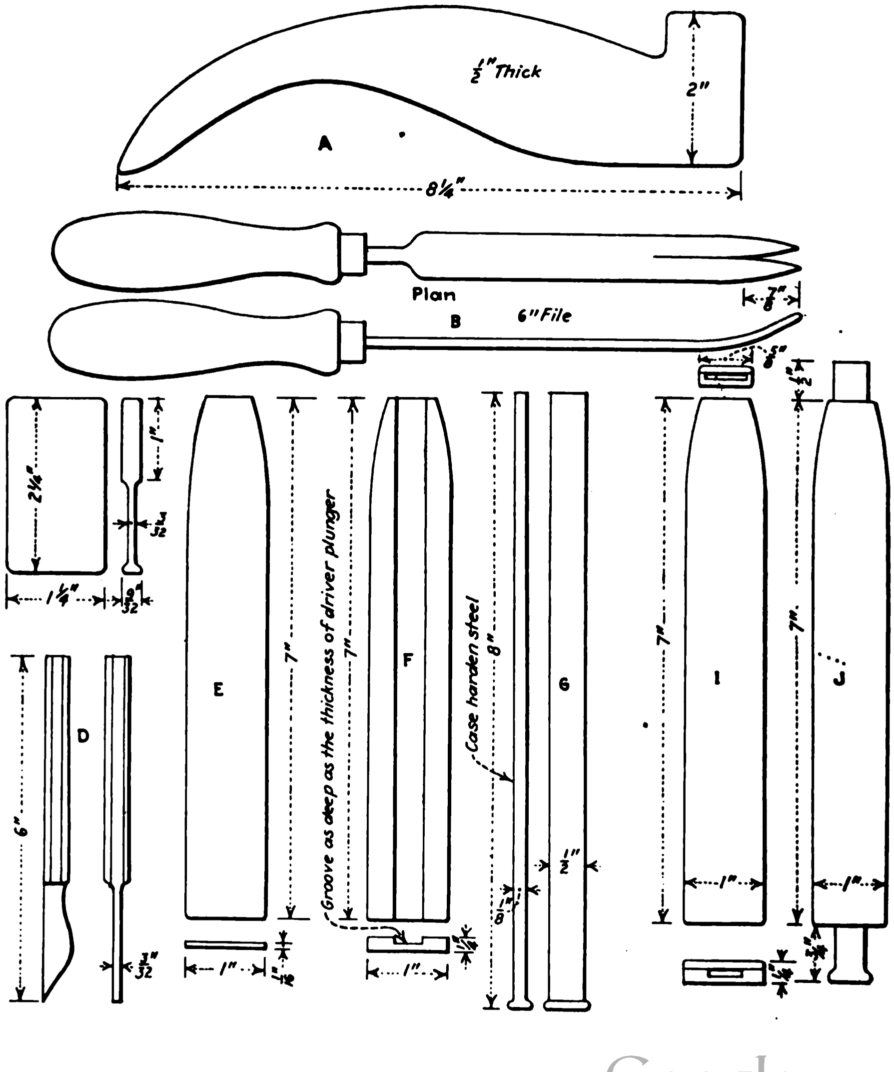
Next, heat up one end of the file red hot and bend it as shown in the illustration. Sharpen the cutting edge of the V, and after the end of the file has been tempered, the cutting edge should be resharpened with a stone so that it has an edge that will cut like a razor.

The packing tool shown above tool at *D* is used in pushing and packing the coils in semi-closed slots. A file may be used to shape a piece of soft iron but a better tool can be made by shaping a piece of steel on a planer.

A cold chisel or a punch flattened out on the end and shaped as shown at *D*, and then tempered, will be found very handy in lifting coil leads out of the commutator segments without heating the soldered connections.

The wedge-driving tool shown at *J* is used to drive retaining wedges in the slots. This tool is a great time saver, and does the work much better than any other method than I have employed. The tool is all made out of steel and the various steps involved in the making of it are shown in illustrations *E* to *J* inclusive. The piece shown at *E* is placed on top of *F* and welded or brazed. The pieces shown at *G* must work very freely in the slot shown at *I*. The tool is shown assembled at *J*.

H. J. ACHEE.
District Line Supt.,
Southwest Light & Power Co.,
Elk City, Okla.



These tools will save time and trouble on difficult jobs.

A coil drift, made preferably of horn fiber, is shown at *A*. The cell paper cutter shown at *B* is made from a 6-in. file. The tool shown above *D* is used to push and pack coils in semi-inclosed slots. A tool which is handy for lifting coil leads out of commutator segments without heating the soldered joints is shown at *D*. The various steps necessary in making the tool shown at *J* are illustrated at *E, F, G,* and *I*.

New Equipment

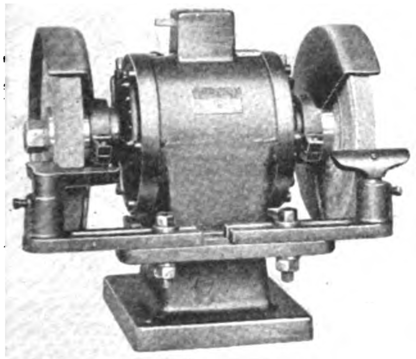
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Ball-Bearing Bench Grinder

PRODUCTION of a line of ball-bearing bench grinders in $\frac{1}{4}$-, $\frac{1}{2}$-, 1- and 2-hp. sizes is announced by the Standard Electrical Tool Co., 1938 West Eighth St., Cincinnati, Ohio. One of the units is shown in an accompanying illustration. This grinder has integral motor drive and is for use on either alternating or direct current. The armature shaft, which also carries the grinding wheels, is made of nickel steel and rotates in ball bearings mounted in dustproof housings.

The switch is located on top of the motor housing, and is of the quick make-and-break type. The wheel sizes range from 6 to 12 in. in diameter. Adjustable arms for tool rests are available in various types, and both rests and arms are detachable. These grinders are also manufactured in the pedestal type.



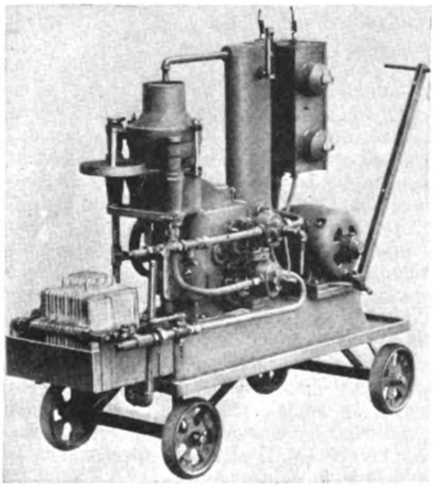
Standard Electrical Tool Co., Ball-Bearing Bench Grinder.

Hydroil Continuous Oil Purifier

ANNOUNCEMENT has been made by the Hydroil Sales Corporation, Lebanon, Ind., of developments and improvements in the portable Hydroil separator, which is a centrifugal separator of the bowl type for cleaning and dehydrating insulating oils, by the addition of a filter. This machine, it is stated, is designed and built especially for use in connection with the purification of insulating oils. One of the new model portable units is shown in an accompanying illustration.

This unit consists of a centrifugal separator, which is mounted on a platform, together with its motor, pump, immersion electric heaters to raise the temperature of the oil to the point where the most complete dehydration is obtained, and control equipment for the motors and heating equipment.

This new model is provided with a filter press for use in dehydrating and cleaning circuit breaker and switch oils. This filter press is shown attached to the rear end of the equipment. In use, the centrifugal dehydrator removes the water, and the filter press takes out any carbon particles or other impurities that may pass through the dehydrator. It is stated that because the water has already been removed, the filter sheets do not get wet and so do not have to be changed as frequently as when used to remove both water and impurities. This equipment is connected by a valve arrangement so that the filter press may or may not be used, as desired.



Hydroil Portable Continuous Centrifugal Oil Separator with Filter Press.

In the purification of transformer oil, the unit, according to the manufacturer, may be connected to the transformer chamber to circulate the oil through the dehydrator and filter if necessary, and back into the transformer, or into a storage chamber, as desired. The capacity of the unit shown is 100 gal. per hr. Two 3-kw. standard immersion heaters and a $\frac{3}{4}$-hp. ball-bearing motor are used. Rubber-tired wheels are used on the new unit.

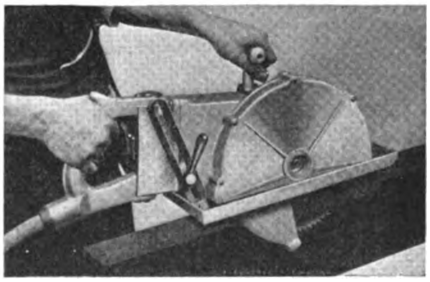
Power Handsaw

MANUFACTURE of a portable electric handsaw for use on construction jobs and in industrial plants, is announced by the Wappat Gear Works, Market St. at Braddock Ave., Pittsburgh, Pa. The saw, which is shown in an accompanying illustration, is distributed under the trade name of the Alta Power Saw. It is claimed that one man with this saw can, in a given time, cut as much lumber as ten men with ordinary handsaws. Heavier material that must ordinarily be carried to a table saw can be cut off or ripped with this portable saw, thereby reducing handling time. The saw is equipped with a 9-in. blade and cuts 3-in. material.

The outstanding feature of the Alta saw, according to the manufacturers, is the safety guard. A circular saw, whether idle or revolving, is dangerous. The blade on the Alta saw is completely enclosed by a telescopic guard which automatically opens only when the saw is pushed into the material and automatically closes again when the cut is completed. This guard serves both to safeguard against accident and protect the blade from damage.

The wide carrying shoe supports the tool and prevents tipping, thereby limiting the operator's effort to mere guiding. A blast of air from the motor ventilating fan is directed to the front of the saw to blow the sawdust away. The shoe is adjustable, so that it is possible to set the saw for any depth of cut.

A $\frac{3}{8}$-hp., 110- or 220-volt, universal-type motor which operates from an a.c. or d.c. power socket, is used. It is stated that the Timken tapered roller bearings and the worm gear drive result in quiet operation and a minimum of wear.



Portable Alta power handsaw manufactured by the Wappat Gear Works.

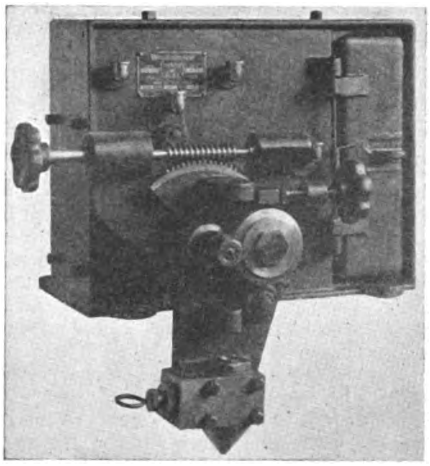
Automatic Arc Welder

A NEW machine designated as the Auto-Arc, for automatically feeding a continuous welding wire, used in metallic electrode welding, has been put on the market by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. This machine is suitable for feeding the wire to the work at any speed up to 3 ft. per minute, and it is claimed that it strikes the arc automatically and, if necessary, will exert a pull on the wire of approximately 200 lb. in order to prevent fusion of the electrode wire to the work.

The arc length can be adjusted so that it will be maintained at an average value of from 15 to 20 volts, and it is also claimed that the arc will remain almost constant at any given voltage. The $\frac{1}{4}$-hp. feed motor and the electromagnets do not obtain power from the arc circuit, and are therefore selected large enough to feed any size wire up to $\frac{3}{8}$ in. in diameter. Certain parts of the machine are inclosed in a dirt-proof

housing, and all parts are said to be very accessible.

This automatic arc-welding equipment can be used to best advantage on work requiring the welding of long



Westinghouse Auto-Arc Welding Machine.

continuous seams, in production manufacturing operations, and also for some repair applications such as building up worn cross-heads, cross-head guides and valve guides for locomotives. It is also applied in building up worn flanges for yard locomotives and street railway car wheels.

Flood-Light

THE FL-300 flood-light unit shown here has recently been designed by the Pittsburgh Reflector Co., 304 Ross St., Pittsburgh, Pa., for mounting relatively close to the surface to be illuminated, approximately 10 to 20 ft. therefrom. It was designed particularly with a view to installation upon lighting standards at the curb in front of a building.

This light consists of a metal base, a semi-spherical metal casing, a cowl and focusing equipment, a reflector and cover with heat-resisting cover glass. The unit has a mogul socket carried on a focusing mechanism making possible movement of the lamp in all directions, which permits accurate focusing. The cover and casing are threaded so that the cover may be screwed on. Consequently, no hinges are necessary.

This light is designed for use with a 300-watt standard Mazda C lamp, but by the use of a socket reducer a 200-watt lamp may be used. An up-and-down focal adustment extends over a range of 2 in., in order to permit the use of the 200-watt lamp.

Ball-Bearing Worm-Gear Speed Reducers

ANNOUNCEMENT is made by Foote Bros. Gear & Machine Co., 236-246 North Curtis St., Chicago, Ill., of the development of a new line of high-efficiency worm-gear reduction units with ball or roller bearings, which are being marketed under the trade name of Hygrade Type HG worm-gear reducers.

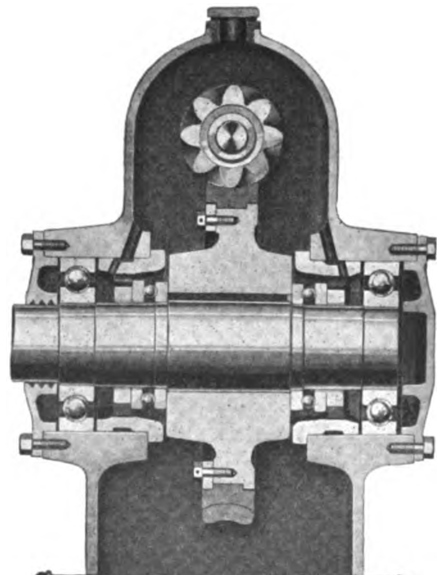
One of the important points, according to the manufacturer, is that all of the parts for the different types in which the line is made are interchangeable except for the cases. The Hygrade line comprises machines of the Type HGS with worm at the bottom, Type HGT with worm at the top, Type HGV with the worm shaft in a vertical position, and Type HGD, which is a double-reduction unit that permits the use of the very high ratios that are required in some installations.

All of these machines are supplied as standard with ball bearings and worm gear and worm gear shafts, for both radial and thrust load. The bearing mountings are shown in the two accompanying illustrations. The manufacturer is also prepared to furnish these units with radial roller bearings when specified, and in some cases with babbitted bronze bearings when these are preferred.

In the double-reduction unit, Type HGD, the high ratios of reduction, ranging from 50:1 to 10,000:1, are secured by the use of two worm-gear trains in series. The initial reduction is secured by a worm and gear of comparatively small size and pitch inclosed in a unit housing that can be bolted to the frame of a standard HGS, HGT or HGV reducer to provide for the larger reduction ratios.

It is well known that efficiencies of the ordinary worm reduction unit at ratios from 50:1 to 100:1 are quite low, and by using the double-reduction unit in such cases, a high average efficiency for the entire installation can be maintained.

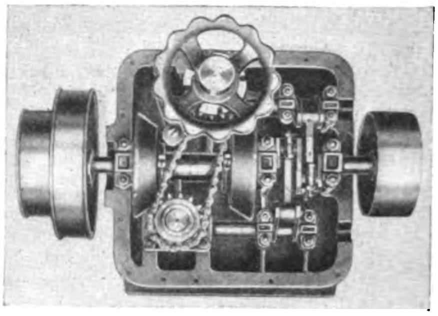
The addition of these units, the manufacturer states, completes the Foote IXL line, which includes spur, worm, and herringbone reduction units ranging in size from fractional horsepower up to 200 hp. in capacity, with a wide variation in the reduction ratios that can be obtained.



Foote Hygrade Type HG Worm Reduction Unit.

Variable-Speed Transmission

MARKETING of a mechanical variable-speed reducer has been announced by the Driscoll Transmission Corporation, 416 West 33d St., New York City. The manufacturer



Driscoll 1 - hp. Variable - Speed Transmission.

states that the transmission, when placed between any prime mover and the driven machine, will take the speed of the prime mover up to 1,750 r.p.m. and deliver any desired speed down to zero. The unit is rated at 1 hp. Changes in speed can be made without interruption of power, by means of a hand-wheel. All moving parts operate in a bath of oil in a dustproof case. The steel parts are heat-treated.

The description of the device, as given by the manufacturer, is as follows: No gears, belts, chains or friction disks are employed. Instead, the operation is by means of two variable-throw cranks that oscillate sleeves carrying quick-acting clutches. The other halves of the clutches are keyed to the driven member, which is rotated by the impulses transmitted through them. The clutches use rollers with double eccentrics to obtain quick locking and unlocking action. In the illustration, which shows an experimental model, the two driving clutch disks can be seen with the cranks and connecting rods between. In the improved commercial model, the clutches are mounted back to back.

1-Ton Electric Hoists

MARKETING of a new 1-ton electric hoist is announced by The Harrington Co., Seventeenth and Callowhill Sts., Philadelphia, Pa. The distinctive features of this hoist, as stated by the manufacturer, are its light weight, compactness, low headroom, and the universal method of mounting which permits its use in connection with hook or trolley. A 2½-hp. universal, series-wound motor drives the hoist.

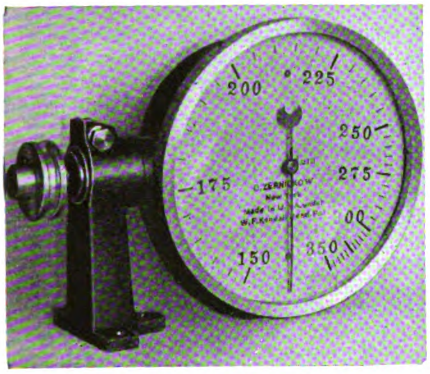
A load chain is used instead of a wire cable. This, according to the manufacturer, enables the hoist to make almost any lift without the use of a special drum, and also permits the hoist to pull loads in underneath it, which enables it to serve a larger floor area. The gear train consists of two pairs of spur gears and worm and worm wheels, all of which are enclosed in an oil-tight compartment. Ball bearings are used on the motor, worm and thrust.

Stationary Indicating Tachometers

ADDITION of a dial-indicating type of stationary tachometer to its line of O-Z instruments, is announced by O. Zernickow Co., 15 Park Row, New York, N. Y. The Model A stationary tachometer is shown in an accompanying illustration. The manufacturer states that these instruments are sensitive and accurate to within ½ of 1 per cent at any point of the scale. The operating principle is similar to the centrifugal pendulum construction as embodied in the O-Z hand tachometer.

Standard range is from 2 to 16 times the minimum speed either for r.p.m. or f.p.m. speeds. For example, 100 r.p.m. minimum speed and 200 r.p.m. maximum speed is a range of 1:2; 100-1,600 r.p.m. is a range of 1:16. Tachometers with higher ranges can be made to order.

These stationary tachometers have a 6-in. dial, are mounted on a bracket with a grooved driving pulley, and are designed for use wherever it is necessary to indicate operating speed. The pulley may be mounted at the right, left, top, or bottom of the dial. The



Zernickow Model A Stationary Tachometer

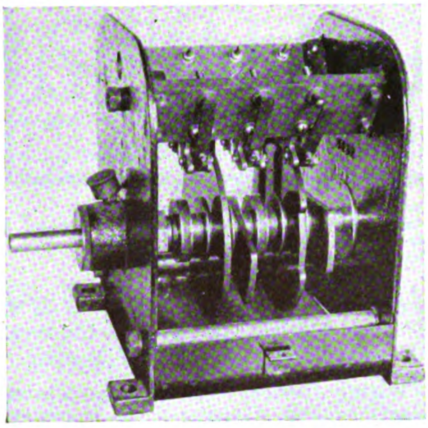
manufacturer recommends driving these tachometers by means of a spring belt. Other methods of drive may be arranged; for instance, direct-connected or flexible-shaft drive. This unit is made in two models. Model A, shown here, has the hand mounted in the center and a circular graduation over the entire circumference of the dial. It is recommended for normal conditions.

In Model B the hand is mounted below the center and the dial has semicircular graduations. This type, it is stated, is especially made to stand rough usage, where violent fluctuations or sudden starts and stops are encountered.

Rotating Cam Limit Switch

A ROTATING cam limit switch to be used with magnetic controllers for the automatic control of machines having a fixed sequence of operation and slowing down, stopping and reversing, has been announced by the Electric Controller & Manufacturing Co., Cleveland, Ohio.

This switch is totally inclosed, is equipped with tapered roller bearings



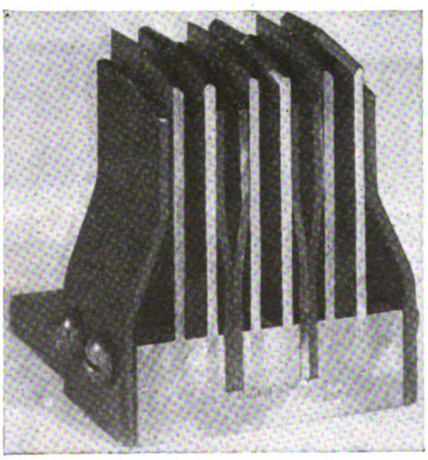
Rotating Cam Limit Switch Made by the Electric Controller & Manufacturing Co.

and is designed to carry up to six sets of contacts. Each of the cams that operate the opening and closing of the contacts is adjusted independently of the others.

Reinforced Switch Jaws

SWITCH jaws of a stronger type have been developed by the Reinforced Switch & Manufacturing Co., Pittsburgh, Pa. The accompanying illustration shows the general construction of the reinforced multiple switch jaw, although some of the details are not visible therein. Steel reinforcing is mounted between the several sets of jaws in such a manner that pressure is applied to the sides of the jaws, causing them to press firmly against the sides of the switch blade when the switch is closed, thus maintaining a uniform contact between jaws and blades, according to the manufacturer.

Both the switch jaw and the steel reinforcing springs are set in grooves cut in the block, and are held firmly in place by two ¼-in. pins that extend through the block. The ends of the holes through which the pins are driven are tapped and threaded for 14-20 screws. Between the contact surfaces where the steel springs would normally press upon the jaws, fiber insulation is inserted, so that the steel does



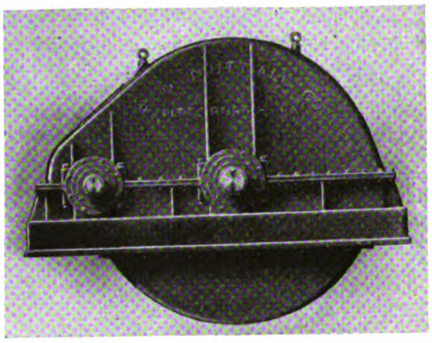
Type of Switch Jaws Developed by Reinforced Switch & Manufacturing Co.

not act as a conductor when the switch is closed. Pieces of Bakelite are used in the lower part of the outer switch jaws, and they act as a stop.

Reduction Gear Units

THERE has just been developed and placed on the market by the R. D. Nuttall Co., Pittsburgh, Pa., the MS and MR series of reduction gear units for heavy service. In this series there are six units that range from 150- to 2,000-hp., rating and are designed for services that require the transmission of heavy loads at relatively high speed, such as on the main and auxiliary drives in steel mills, and in driving crushers, hoists, pumps, etc.

These units are equipped with either Nuttall 7½ deg. single helical or Nuttall herringbone gears, treated or untreated, depending on the application. They are furnished as desired with either sleeve or Timken tapered roller bearings. It is possible to replace one type of bearings with the other because the bearing housings are identical in both types. However, in case of a



Nuttall Series MS and MR Reduction Gear Units.

change of bearings new shafts would have to be provided.

The gears are totally enclosed in a cast-iron case, the bottom of which serves as a reservoir for the lubricant. The gears run in a bath of oil, whereas the bearings are lubricated by a positive splash system. The same lubricant is used for both the gears and the bearings.

Time-Delay Attachment for Compensators

A NEW time-delay attachment, announced by the General Electric Company, is designed for use with hand-starting compensators to provide undervoltage protection during brief disturbances in industrial power circuits. It can readily be mounted in the same supporting holes as used for the standard undervoltage release. Time delay is accomplished by a falling solenoid plunger whose downward movement is retarded through a rack by a flywheel. Upward movement of the plunger disengages the rack from the flywheel pinion, permitting an instantaneous movement. The time delay is about one and a half seconds, and if power returns in less than that time, the starting compensator is not tripped.

Trade Literature
you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Limit Stops—Bulletin 1037-B illustrates the type B limit stop for alternating- and direct-current motors, in connection with hoists on electric cranes, door hoists and other motor-driven equipment which must be automatically stopped after reaching a given point.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Gears—A booklet entitled "Ganschow Gears," gives an illustrated story of the origin and present organization of the William Ganschow Co., which is engaged in the production of industrial gears and worm and planetary speed transformers.—The William Ganschow Co., 18 N. Morgan St., Chicago, Ill.

Lead-Base Babbitt—Folder F 4474-A, discusses the use of and care to take in the application of Alloy No. 25 Westinghouse lead-base babbitt.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Unit Heaters—A 35-page catalog illustrates the Johnson Unit Heaters, shows their construction and method of installation and illustrates, graphically, the advantages claimed for their use.—Johnson Fan & Blower Co., 1319-1325 W. Lake St., Chicago, Ill.

Herringbone Speed Reducers—Catalog 100 covers the line of IXL continuous-tooth herringbone speed reducers which are made in capacities up to 150 hp. and reduction ratios up to 250:1.—Foote Bros. Gear & Machine Co., 220 N. Curtis St., Chicago, Ill.

Group Drives — A booklet entitled, "Group Drives More Economical for Most Drives," contains a reprint of an article by L. H. Hopkins, consulting transmission engineer, as well as the opinion of several eminent engineers.—Chas. A. Schieren Co., 37 Ferry St., New York, N. Y.

Coal and Ash Handling—Book 530 consists of a reprint of five articles which appeared in *Power* and were entitled, "Modern Methods in Coal and Ash Handling."—Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

Platforms—Catalog 684 covers a line of Truscon alloy-steel boxes and platforms for holding or handling materials by means of lift trucks, cranes, or other methods of handling.—Truscon Steel Co., Youngstown, Ohio.

Potheads—A circular illustrates the types of G & W potheads of the disconnecting, tapnut-terminal, non-disconnecting, and indoor-use-only types which are made in ten different shapes. A special cable support is shown which, it is said, is applicable to vertical or horizontal runs and does not scratch the cable or wear the sheath.—G & W Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Wiring Devices—A 172-page catalog describes and illustrates the complete line of 4,000 wiring devices, together with the catalog numbers, a price list and a general index.—The Bryant Electric Co., Bridgeport, Conn.

Speed Reducer—A leaflet describes and illustrates a new type of speed reducer which employs a set of spur gears mounted on three shafts.—Palmer-Bee Co., Detroit, Mich.

Friction Clutches—The 70-page Catalog 17 describes the line of Falls friction clutches, which are manufactured by The Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio. The entire Falls line of elevating, conveying and power transmission equipment is now a division of The Kent Machine Co., Kent, Ohio.

Air Filter — Bulletin 2223 discusses the Sirocco dry-plate air filter in which the air passes through a number of parallel plates in each filter section. Due to the staggered openings in the plates and the consequent reversal of direction of air, the dust loses its velocity and either builds up on the surface of the plate or falls to a retaining chamber in the bottom of the section.—American Blower Co., Detroit, Mich.

Automatic Compensators — Bulletin 1042-F describes and illustrates the E C & M automatic compensators for use with 110- to 550-volt a.c. squirrel-cage and synchronous motors.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Pneumatic Collecting and Conveying Systems — Catalog 291, third edition, devotes 72 pages to a description of pneumatic equipment, and contains a large amount of descriptive and engineering data.—B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Ball Bearings—"The Dragon" is a monthly publication devoted to stories of Fafnir ball-bearing applications on various types of equipment used in different industries.—The Fafnir Bearing Co., New Britain, Conn.

Air Filter—A circular describes the new Midwest Self-Clean air filter which consists of an application of Midwest filters on an endless chain with a self-cleaning device.—Midwest Air Filters, Inc., Bradford, Pa.

Graphic Instruments — Catalog 406 devotes 70 pages to a discussion of the general and special features, as well as detailed specifications of the various types of Esterline-Angus graphic meters, accessories and supplies, as well as their inspection and instrument repairs.—The Esterline-Angus Co., Indianapolis, Ind.

Power Hand Saw—A circular describes and illustrates the application of a portable electric hand saw with universal motor, which, it is stated, will cut material up to 3-in. thickness.—Wappat Gear Works, Pittsburgh, Pa.

Oil Storage—A 60-page catalog illustrates applications of the various Bowser tank storage and distributing systems for lubricating oils, paint oils, and other liquids used around industrial plants.—S. F. Bowser & Co., Inc., Fort Wayne, Ind.

Portable Electric Tools—An 8-page circular illustrates the various Van Dorn portable electric tools, as well as floor and bench grinders.—The Van Dorn Electric Tool Co., Cleveland, Ohio.

Power Transmission Association Offers Prize for Emblem

THE Power Transmission Association has offered a prize of $250 for the best slogan emblem design for the association which is received on or before June 5, 1927. The American Society of Mechanical Engineers has been asked to name a committee of three to select the person or persons whose ideas are entitled to the award. The name of the winner will be announced at the National Industrial Advertisers Association convention in Cleveland, Ohio, June 15.

The wording should typify the objective of the association in the fewest possible words, with a striking action design, showing some application of or relation to *mechanical power transmission*. It is hoped to obtain an emblem or slogan insignia that can be used on all advertising or letters of the association or of any concern making equipment or materials used as mediums for the mechanical transmission of power. What is desired is something as effective and striking as "Save the Surface," or "Say It With Flowers" or similar emblems. Ideas are wanted: not necessarily a finished drawing.

The object of the Power Transmission Association is to determine and foster the right drive or use of mechanical power transmission for any given installation in any factory, shop, or place where power is used to drive machines. That is, the most efficient and economical use of mechanical power transmission mediums is sought. By mechanical power transmission mediums is meant belts and pulleys, shafting, gears, clutches, chains or any means of transmitting power mechanically.

This offer adds another to the long list of fine awards that are to be announced at the National Industrial Advertisers meeting in Cleveland to be held at the Hotel Statler, June 13-15.

Send your ideas, sketches and suggestions for this $250 award for its slogan emblem to the Power Transmission Association, Drexel Building, Philadelphia, Pa., on or before June 5.

Volume 85 New York, May, 1927 *Number 5*

G. A. VAN BRUNT
Editor
D. H. BRAYMER
Consulting Editor

INDUSTRIAL ENGINEER

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

A. J. WHITCOMB
Contributing Editor
F. E. GOODING
G. H. FAIRBANKS
Associate Editors

Contents

Departments

Enlarging Our Service to American Industry

In ORDER to give American industrialists and engineers first-hand information on the deliberations and conclusions of the coming International Economic Conference, the McGraw-Hill Publishing Company is sending Edward J. Mehren, one of its vice-presidents, to this important meeting. This Conference will be held at Geneva, Switzerland, beginning May 4, under the auspices of the League of Nations. Five delegates have been appointed by President Coolidge and will be accompanied by experts selected from governmental departments.

The purposes of this conference are, to determine the economic difficulties that are preventing the revival of general prosperity, particularly in Europe, and to ascertain the best methods of overcoming these.

The topics for study fall under four heads:

(1) An analysis of economic causes of the present disturbed equilibrium in commerce and industry, and a study of the economic tendencies capable of affecting the peace of the world.

(2) Commerce questions, such as tariffs, import and export prohibitions and restrictions, monopolization and limitation of trade, dumping legislation and subsidies.

(3) Industrial problems, such as the situation of principal industries relating to productive capacity, output, consumption and employment; production statistics, etc.

(4) Agriculture and its difficulties.

World trade is becoming increasingly vital to American industries, and as a means of serving these industries Mr. Mehren will report through the pages of the McGraw-Hill publications the results of his studies and observations.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

WASHINGTON, Colorado Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4
Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record — American Machinist
Power — Chemical and Metallurgical Engineering
Coal Age — Engineering and Mining Journal
Ingeniería Internacional — Electrical Merchandising
Bus Transportation — Electric Railway Journal
Electrical World — Construction Methods
Industrial Engineer — Radio Retailing
Electrical West
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 85 New York, May, 1927 *Number 5*

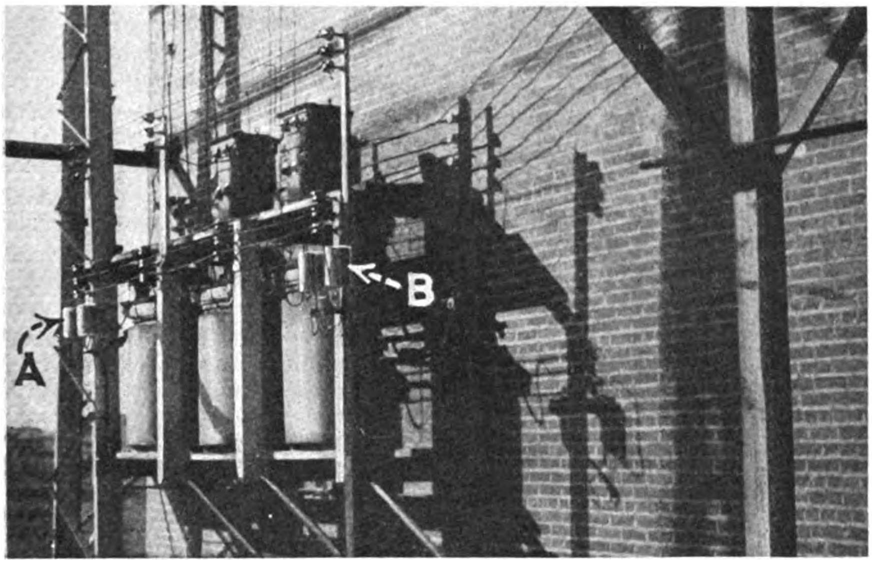


Fig. 1—Outdoor-type instrument transformers are used at this transformer bank. The current transformers are located at A whereas the position of the potential transformers is shown at B. The meter is installed in the building adjoining.

Departmental Metering Practice

In Industrial Plants

BY J. ELMER HOUSLEY
Electrical Engineer, Aluminum Company of America, Alcoa, Tenn.

POWER costs may or may not be a prime factor in determining the profits or sale price of a manufactured article, but in the majority of plants these costs are becoming more important as production is speeded up, with a corresponding reduction in man-hours per unit produced.

Power is a commodity the same as any other raw material entering into manufacturing processes and no relation between its consumption and department production can be established without departmental metering. Changes are constantly taking place in the condition of the equipment in each department; friction will vary or temperature conditions may alter the load on many machines so that, other things being constant, the power consumption reflects the changes in the condition of equipment, and indicates when and where an investigation or test is required. Furthermore, in a progressive, growing plant changes and alterations are constantly being made to both equipment and methods, and the question of whether power consumption has been increased or decreased frequently arises.

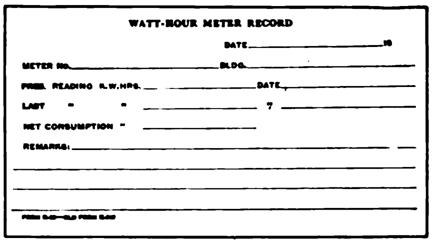
Metering the electric power delivered to the various departments of an industrial plant takes the pulse beat, so to speak, of each member of the plant family, so that each department may be placed on a sound footing, from the standpoint of operation, and encouraged to better endeavor. The results anticipated by a change in manufacturing methods or equipment may be weighed in the balance by the meter. In some cases increases in power consumption indicate a conservation of man-power, a liberation to direct larger activities; perhaps the relation of kilowatt-hours required to replace a man in one department or another may be the yardstick required to compare results.

Departments should be charged with the power used to prevent

waste of power, if for no other reason. Incentive is a great driving force if properly applied and when a definite billing is made against a department an incentive is given to that department to reduce its power bill. If it is a laboratory, the hot plates will be cut off when they are not required for an hour or so. If it is a shop, the various power tools will be shut down when not in use, or the drives may be regrouped to prevent running a 50-hp. lineshaft motor in order to operate a lone power hacksaw. Thus results in the way of saving power that could never be produced by direct orders will gradually be brought about by a careful check on power consumption. To say the least, power is expensive whether it is purchased or generated, as a by-product or in a hydro-electric plant. The capacity required to furnish the power is, in the last analysis, about as great in one case as another; and capacity plus operating charges means the interest on $100 to $200 for every kilowatt demanded at one time, plus a variable operating charge per kilowatt-hour. Cost acountancy must take account of all items of cost if anything is to be known regarding the cost of producing an article of commerce. For accuracy the power must be metered as a whole, subdivided into departmental units and metered again in order to pro-rate properly the departmental charges for the power consumed.

The mechanism for gathering the data concerning the power used by each department may be either simple or very complex, depending on the inter-relation of departments. In the design of a new plant or the revision of an old one the provisions for adequate and satisfactory metering may easily be made. The size of the plant and the amount of power used in each department determines the layout to be used. The logical place to install metering equipment, is of course, at the source and again at each of the load distribution centers. The latter may be in the substation or power house, in the small plant, or they may be at distant points in the larger plants. A choice must also be made between metering on the high-tension side or the low-tension side of the distribution transformer bank.

Where only one metering equipment is to be installed at the transformer bank for small blocks of


WATT-HOUR METER RECORD

DATE ________ 19

METER NO. ________ BLDG. ________

PREV. READING K.W.HRS. ________ DATE ________

LAST " " ________ " ________

NET CONSUMPTION " ________

REMARKS: ________

Fig. 2—Watt-hour meter readings of power consumption are recorded on this card.

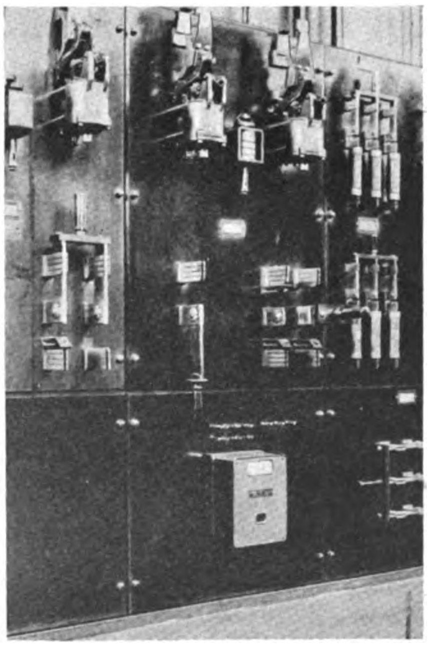
The location of the meter is recorded, with its serial number, the date read, and the dial readings. From the previous reading the net consumption is calculated.

power and for temporary installations, the outdoor, 2,200-volt installation is quite common. The equipment consists of two potential transformers and two current transformers, with a suitable meter. Suitable brackets are needed for attaching the transformer to crossarms, or other structures, and a metal box, well grounded should be supplied to house the watthour meter, which should be mounted near the ground on a pole, tower, or adjacent building, as the case may be. An installation of this type is shown in Fig. 1. In this instance the meter is located inside the building. Most of the trouble experienced with this type of installation can usually be traced to lightning.

With this method of metering, the

Fig. 3—Switchboard type meter installation for registration of primary power.

This shows the potential test terminals to the right, and the current test terminals mounted directly above the meter on the face of the panel to facilitate routine testing.



transformer losses are measured and charged to the department as power consumed. It is the rule in many plants to segregate the total line losses and charge them into general plant accounts as they naturally fall into overhead expense. The line losses for the plant, obtained by subtracting the total energy consumed, as registered by the sum of the department meters, from the total energy registered by the master meter at the source, indicate whether any departmental meter or the master meter is out of order. Any great change in line loss, which is a rather uniform percentage of the total load, indicates incorrect registration of some meter. In one large plant, a blown potential fuse on a meter was detected by a change in the line losses and corrections were made to the incomplete meter reading that were within 5 per cent of the actual value, as the line losses were known for different operating periods.

At times one department, B, may be situated so that it is at the end of a distribution line to another department, A. In order to save the heavy expense of a duplicate feeder to serve a light load a meter is installed in department B. The meter for department A will then register the total power taken by both A and B, so in this case the power consumption is obtained by indirect reading, that is, subtracting the consumption of B from that of A to sesure the net consumption for the latter.

The monthly meter readings may be kept in a standard form of meter book, some of which provide space for the numerical dial reading, whereas others have a printed meter index for every reading so that lines drawn on the printed index indicate the exact position of the dial hands at the time of reading. For reporting the meter readings, the meter reading card shown in Fig. 2, is used.

Before developing a system of metering for a plant in operation, a comprehensive survey should be made of the connected loads. These should be grouped to include the natural departmental divisions, such as power house auxiliaries, plant water pumping, machine shop, and allied facilities, and process groupings. These are given as suggestions indicating some of the natural divisions. The proposed grouping must next be reconciled with the existing electrical plant wiring dia-

gram, which will be similar to that shown in a previous article on page 358 of the August, 1925, issue of INDUSTRIAL ENGINEER, by a rearrangement of circuits, if this is necessary.

If a motor test record is available covering the motor installations a study of the peak and average loads per group will be greatly simplified. Such a study will usually prove to be of much interest and value even if the proposed metering plan is later abandoned. For stabilized departments, such as the shop facilities and water pumping, the metering equipment may be considered as fairly permanent because no great change will be made except in the case of a complete enlargement of the entire plant. Very little excess capacity in the metering equipment would be necessary for such departments. In the process departments much greater latitude should be allowed and an excess of capacity ranging from 20 to 40 per cent may be provided, depending on the nature of the plant. Operations may be regrouped, expanded or otherwise altered as has been mentioned previously.

METER TEST RECORD

MAKE ______ TYPE ______ SERIAL NO. ______

AMPS. ______ VOLTS ______ WATTHOUR CONSTANT ______

LOCATION BLDG. ______ DEPT. ______ RECORD NO. ______

DATE	REV. STANDARD METER	REV. SERVICE METER	PER CENT SLOW	PER CENT FAST	REMARKS

FORM Y-287-E.

Fig. 5—Here is a secondary meter test record card.

On this card the meter nameplate data and results of periodical tests are recorded.

MADE IN U. S. A.
421 1M-10-25

METER TEST RECORD

MFG. General Electric Co. SERIAL NO. 4868081

LOCATION No 3 Generator VOLTS 13200/110 AMPS. 150/5

WIRE 3 PHASE 3 TYPE DS-6 CYCLE 60

METER CONSTANT 1000 READING ✓ 0000

CONDITION OF METER

CASE OK DIAL OK SEAL None JEWEL OK

GEARS OK MAGNETS OK DISC OK CREEP No

CURRENT TRANSFORMERS				POTENTIAL TRANSFORMERS			
MFG.	GE. Co	TYPE	—	MFG.	GE. Co	TYPE	—
SERIAL No.	—	RATIO	30/1	SERIAL No.	—	RATIO	120/1
VOLTAMPERES	200	CYCLE	60	V. A.	—	VOLTAGE	—

REMARKS Meter has a tendency to run slow. Bearings Were Oiled, magnets cleaned and re-adjusted 5-17-26

TESTER James L. Reed

TEST RECORD

DATE	LOAD 10%	LOAD 50%	LOAD 100%	REV. STD. MTR. 10%	REV. STD. MTR. 50%	REV. STD. MTR. 100%	REV. SER. MTR. 10%	REV. SER. MTR. 50%	REV. SER. MTR. 100%	RATIO	ACCURACY % S.	ACCURACY % F.
1-20-26	✓	✓	5	✓	✓	9.20	✓	✓	9	97.8	2.2	✓
3-17-26	✓	✓	5	✓	✓	9.10	✓	✓	9	98.9	1.1	✓
9-20-26	✓	2	5	✓	8.93	8.93	✓	9	9	100.7	✓	0.7
11-11-26	✓	✓	5	✓	✓	8.85	✓	✓	9	101.9	✓	1.9

Fig. 4—This is the primary meter test record card.

On the front of the card, the nameplate data of the meter and instrument transformers used are recorded, with a note on the condition of the meter when installed. On the back of the card the results of periodical tests are recorded for purposes of comparison.

Within the range of circuit capacity, the current transformer ratios should be selected in evenly spaced groups so that in case the metering capacity is exceeded it is necessary only to transfer current transformers from one installation to another, should the loads increase progressively. It sometimes works out that a set of 600-amp. transformers are bought to replace those in a 400-amp. installation which may be used to relieve some 200-amp. transformers, and so on down the line, indicating that the general trend is toward increased power consumption in all departments of the modern industrial plant.

The typical plant circuit for distribution to motors is operated at 440 volts, three-phase, 60 cycles, and it follows that the typical metering equipment for that circuit will consist of two current transformers and a 5-amp., 440-volt meter with a self-contained potential circuit. Of course, meters with self-contained current circuits can be obtained up to 100-amp. capacity or more, but they are unwieldy to handle and a much larger investment is tied up when they are put on the shelf due to the ever increasing loads on the circuit.

As stated before, when selecting current transformers, care should be taken to see that the current ratios are evenly spaced, so that as the circuits become overloaded these transformers may be moved progressively from one circuit to another, as is often possible.

Individual circuits are in general limited by two factors: the economical size of conduit and the largest single body fuse which can be used. It happens that the two coincide and our practice has been to subdivide

the circuits so that the maximum conductor is 500,000 circ.mil in a 3-in. conduit, controlled by a 600-amp. fused, inclosed and externally operated safety switch. In case the maximum-sized circuit takes care of one department the metering equipment is installed in this circuit. If two or more such circuits are required a bus-type transformer may be slipped over the busbar section ahead of the taps for the other circuits. Seldom will more than two departments of large size be fed from one distribution center. In such cases, the second department will be metered by the indirect method as outlined above.

Meters should be checked for accuracy at reasonably frequent intervals, and the accessories needed with the metering equipment include fuses for the potential circuit of the meter and current links for the current transformer circuit. It is well known that a very high voltage is set up in a current transformer carrying load when the secondary circuit is opened, making it dangerous to both the transformer and the person handling the circuit. In view of the necessity of proper testing of meters at regular intervals and the value of a quick and safe method of connecting the test meter in series with the current elements in the installations I have made, two test terminals are connected in the current transformer secondary circuits. Each terminal has two spare connecting nuts under which the leads for the current coils of the test meter are attached between the pair of terminals. In this way the test meter is put in series with the meter under test without opening the circuit when the bridges between the other two bottom nuts are removed. This arrangement of terminals is shown in Fig. 6.

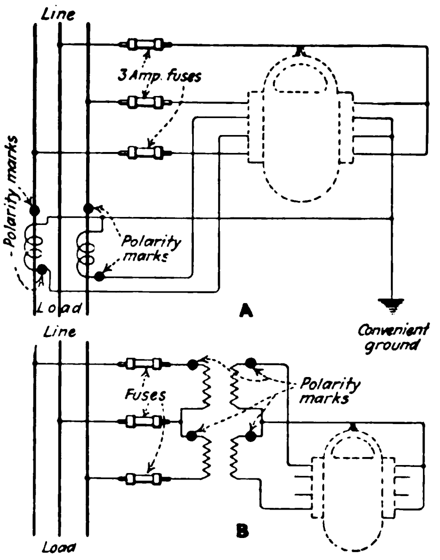


Fig. 7—Connection diagram for three-phase, three-wire meters employing instrument transformers.
The connections in *A* show the use of current transformers and the direct application of line potential through fuses in each phase. In *B*, connections are shown for using potential transformers for medium or high voltages. If required, current transformers would be connected as shown in *A*.

The frequency of testing meters should be adapted to the conditions in the plant and a record should be made of each test that will show the condition of the meter before and after testing. Meters that are important factors in calculating departmental efficiencies may be tested once a month, but the average plant meter should show little variation between yearly tests. If any meters, however, show a considerable variation from test to test, the interval between tests should be decreased until the underlying cause has been ascertained and corrected by whatever means are necessary.

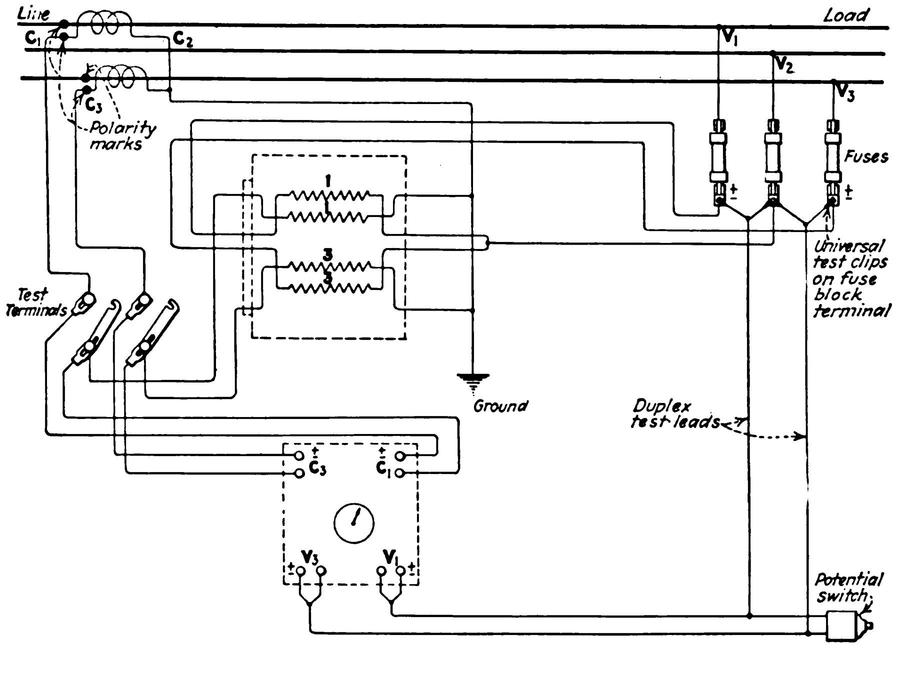
Two meter test record cards are shown in Figs. 4 and 5, and cover test data on primary and secondary meters. In the case of primary meters, the full nameplate data as well as the instrument transformer data are recorded on the front of the card. The back of the card is used for the record of tests made under different conditions of load and on various dates.

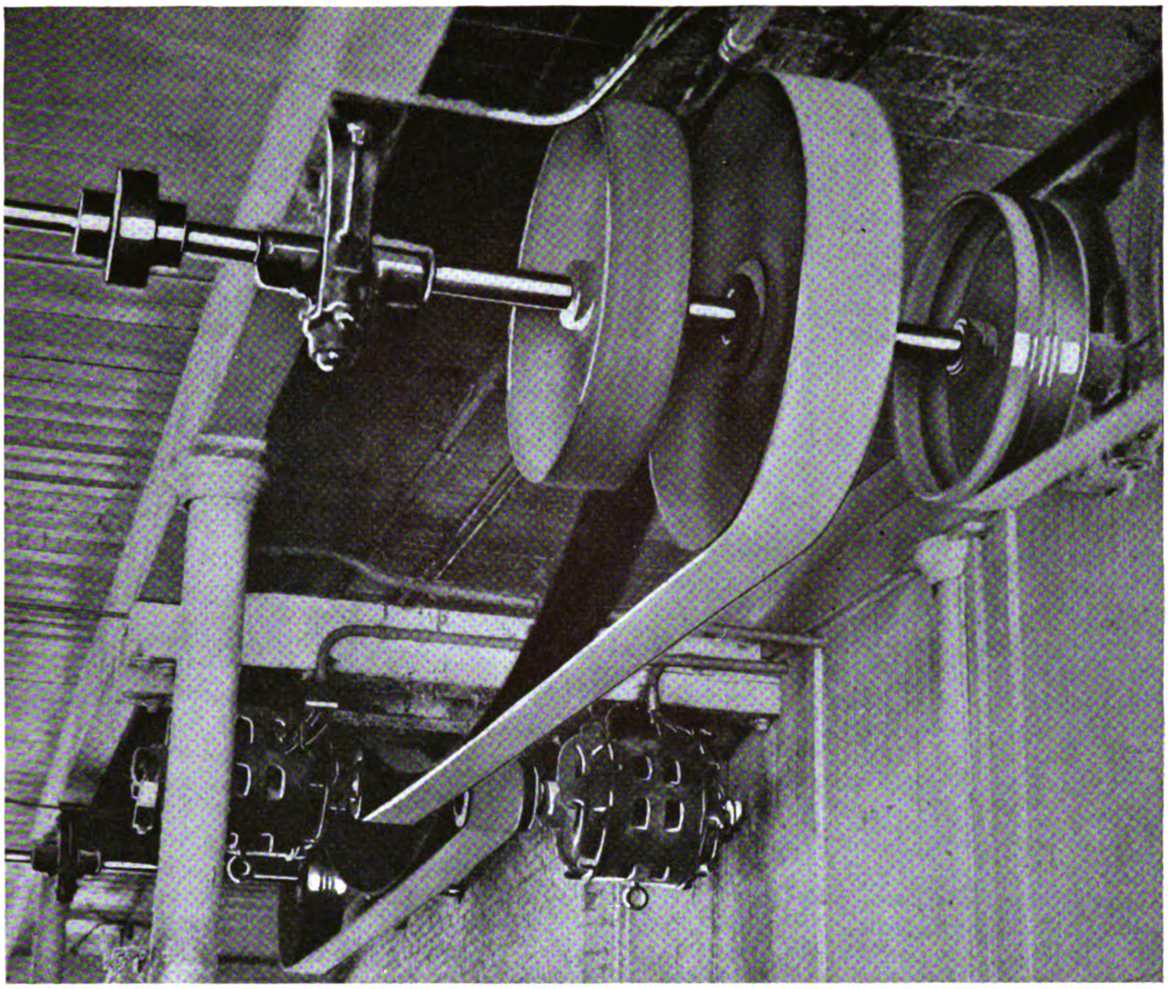
The testing equipment for the field will usually consist of a polyphase rotating standard watt-hour meter with variable voltage and current taps, and a load resistance or phantom load box for testing meters under artificial load. Polyphase meters, which are subjected to variable loads and used where high accuracy is desired at all loads, should be brought into the shop for testing and adjustment. A simple test table with a current source and the necessary switches may be fitted up from ordinary materials at hand, or a special test table may be purchased. However, the average plant will not require a great amount of expensive testing equipment if a standard-type, 5-amp. meter can be used for all installations as is frequently the case.

The wiring diagram in Fig. 6 shows the connections for testing a Type OA, 5-amp., 440-volt, three-phase, three-wire Westinghouse service meter with a Westinghouse polyphase portable rotating standard test meter. The current leads are attached to the rotating standard meter and then inserted in the double test terminals. The removable links may then be opened by unscrewing a floating nut which places the current coils of the standard meter in series with the service meter without opening the current transformer circuit. The wiring may be run on the

(Please turn to page 204)

Fig. 6—Connection diagram for service meter test using rotating standard watt-hour meter.
This diagram shows the connections of a Westinghouse portable, rotating standard meter when used to check a Type OA Westinghouse meter taking service from a 440-volt source and using current transformers. The current coils of the rotating standard are cut into the service meter current circuits by means of the test links, without danger of breaking the circuit.





These 8-in. double leather belts operating on 14-ft., 10½-in. centers have been in 24-hr. service since 1905 in the woolen mills of the Wonalancet Co. The diameter of the motor pulleys, turning at 1,170 r.p.m., is 9 in., whereas the shaft pulleys are 37 in. in diameter.

Factors in determining

Proper Center Distances for Leather Belt Drives

By **ROY C. MOORE**
Chief Engineer,
Chas. A. Schieren Co., New York, N. Y.

TRANSMISSION of power by leather belts is one of the oldest and most common methods used by industry. As with numerous other familiar industrial problems, there are many practices and rules-of-thumb associated with the selection of a belt for a particular application which, as long as they contain a sufficient factor of safety or ample rating, give satisfactory and reliable operation. For all belt work rules can be used only as a basis, because a large proportion of belt installations are not under ideal operating conditions, and so require some modifications to meet the particular situations.

The object of this series of articles, of which this is the first, is not to present a theory of the transmission of power by belting, but to outline conclusions regarding certain factors that will affect satisfactory operation of belts. These conclusions are not based on the results of experiments, but are drawn from experience with, and records of, belts in operation over a long period.

Many of the results given here will, therefore, appear conservative as compared with results of tests, but please remember that the elements of final cost and satisfactory operation have been taken into consideration in outlining the limiting factors. Tests are practically always made under laboratory conditions, while those under which a belt operates are often far from ideal. Also, a test covers a comparatively short portion of the anticipated life of the belt and the real life, even under the test conditions, can only be surmised.

Many of the remarks that follow will be statements of what to avoid doing, in the interest of final cost

and satisfactory operation, rather than what to do. Some of the statements may appear to conflict with good practice, but it must be remembered that where operating conditions are not ideal it would often cost too much to rectify them. When an operating man knows what makes good or bad operating conditions, he can often arrange a new drive so as to eliminate many of the improper conditions. Sometimes this is impossible and, therefore, many drives must be installed to operate satisfactorily under existing conditions. It is for these exceptional drives that the following data will prove of greatest value.

This first article will take up some of the important considerations in connection with determining the proper distance between pulleys. The answer to the question, "How long should a man's legs be?" holds good in every case; the answer, "They should be long enough to reach to the ground," seems to satisfy every condition. How far apart pulley centers should be placed is another matter. A great many factors enter into the solution of such a drive problem and in each case the factors differ; therefore, the solutions also vary.

Inasmuch as it is necessary to maintain an overload capacity for satisfactory service, any condition that will decrease this capacity must be carefully considered. It is evident that with a belt driving from a small to a very large pulley, with a comparatively short center distance, there is only a small amount of belt in contact with the smaller pulley. It is reasonable to suppose that under such conditions the maximum capacity of the belt is lowered, and such has been found to be the case.

Table I—Arc of Contact on the Smaller Pulley

R	Arc of Contact in Deg.	Correction Factor
0	180	1.00
1	175	0.97
2	170	0.95
3	165	0.92
4	160	0.90
5	155	0.87

Table II—Center Distances Found Satisfactory in Practice

Type of Drive	Belt Width in Inches	Distance Between Centers in Feet
Countershaft Drives:		
Small....	2–6	Approx. 10–12
Medium.	6–10	Approx. 14–18
Large..	10 and up	Approx. 18–25
Main drives	12 and up	Not over 35

In all belt drives it is safer from both operating and cost standpoints to be conservative. For example, it is always well to use a moderate center distance, whenever possible. This gives rise to the question, "What is a moderate center distance?" It is readily understood, of course, that what may be a moderate center on one drive may be too short or too long on another drive, depending upon operating conditions. Some of these conditions will be pointed out in this article and illustrated by examples rather than by an attempt to define a moderate center distance, which is only relative and is affected by the circumstances surrounding the installation in any given case.

Pulleys that are slightly out-of-round, for instance, which is often true of improperly installed split pulleys, place an uneven strain on the belt that cannot easily be absorbed unless there is a suitable distance between the pulley centers. In other words, the uneven strain on the belt which is caused by the pulley being out-of-round must be distributed over a fair amount of the belt's length, if the strain is to be properly absorbed and not transmitted on to the next shaft, in a form of a shock load.

Where moderate centers are used the weight of the slack strand of the belt is sufficient to maintain a suitable tension without calling upon much of the belt's elasticity. Where short centers are used, however, the total pressure of the belt on the pulley is maintained largely through the elasticity of the belt. When it is necessary to call upon the elastic properties of a belt to maintain perfect tension, a certain amount of stretch is inevitable and the tension necessary to transmit the load soon falls below the point where it is satisfactory.

The elasticity of the leather in the belt is the physical characteristic of the material that permits it to give or stretch sufficiently to accommodate increased load, or shock load, and again regain its normal condi-

Fig. 2—Examples of belts operating with long center distances under three different conditions.
With the long center distance a comparatively slight stretch resulting in 1 per cent elongation gives enough sag for the slack side of the belt to almost touch the tight or driving side. Shortening the center distance or putting the slack side on the bottom overcomes this difficulty.

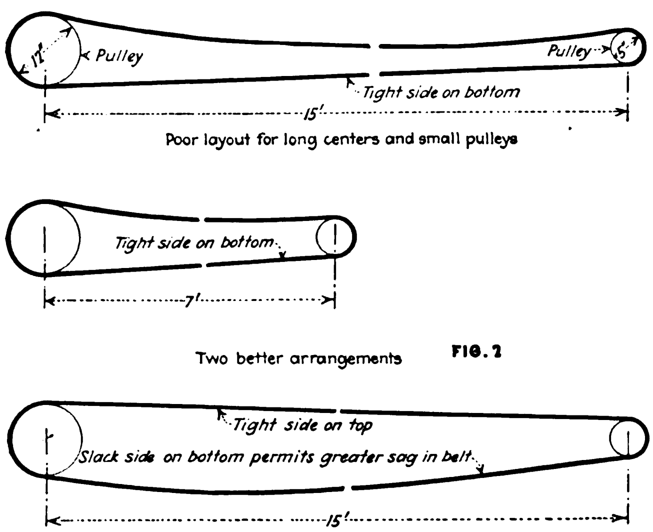


FIG. 2

Fig. 3—Irregular loads cause a strong, wavelike motion in drives with long centers.
With such drives a shorter center distance is more suitable and the addition of an idler will make the drive operate more smoothly.

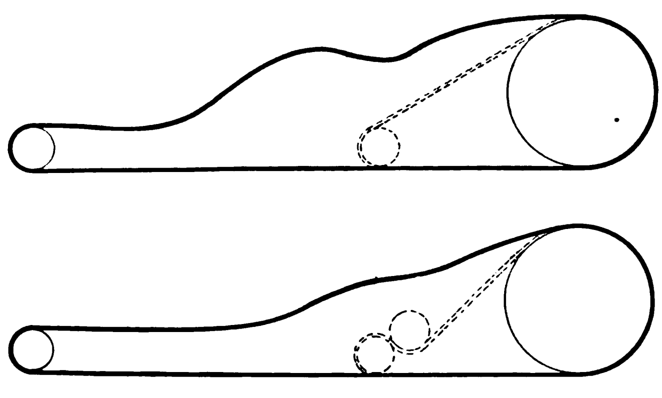


FIG. 3

tion when the increase in the load is removed. However, when the load is greater than the elastic limit of the belt it does not return to its original length; in other words, the belt will have a permanent stretch. Excessively high tension, such as would be necessary on very short centers or when the belt is overloaded, results in excessive stretch, which not only necessitates more frequent maintenance, but also shortens the life of the belt.

From past experience in laying out large compressor drives, and drives with a large difference in diameter between the two pulleys, it has been found that the arc of contact on the smaller pulley should never be less than 155 deg. For good practice it has been found that an arc of contact of less than 165 deg. necessitates running the belt at high tension.

A simple rule that I have used to determine the necessary center distance to give a certain arc of contact on the smaller pulley is as follows: Divide the difference in diameter (in inches) of the two pulleys by the ratio R (Table I) to obtain the center distance in feet. This can be expressed in a formula: $(D - d)$ in inches $\div R = C.D.$ (center distance) in feet. $R =$ difference in diameter of pulleys in inches $\div$ center distance in feet. In case the quotient should come out as a decimal assume the closest unit value for R as given in Table I, and the second column of this table will give the corresponding arc of contact for that installation. As stated, it is highly desirable to get an arc of contact of at least 165 deg., and so values of R which will give at least 165 deg. of contact should be assumed and substituted in the formula until a satisfactory distance is obtained.

Table I gives the arc of contact on the smaller pulley corresponding to the value R obtained by the above formula, and correction factors (third column), that indicate the loss in the power transmitting ability of the drive, compared to a normal drive, because of the decrease in the arc of contact. For example, a drive with a 170-deg. arc of contact will transmit only 95 per cent of the rated belt capacity that would be transmitted if it were operated with a 180-deg. arc of contact. The loss increases rapidly with the decrease in the arc of contact, as may be seen from this table.

Where an excessive center distance would be required to give the desired arc of contact, a short-center drive with a flexible or gravity idler should be used. The application of the short-center drive will be discussed in a later article of this series and so will not be covered further here.

Table II gives a list of center distances that have been found satis-

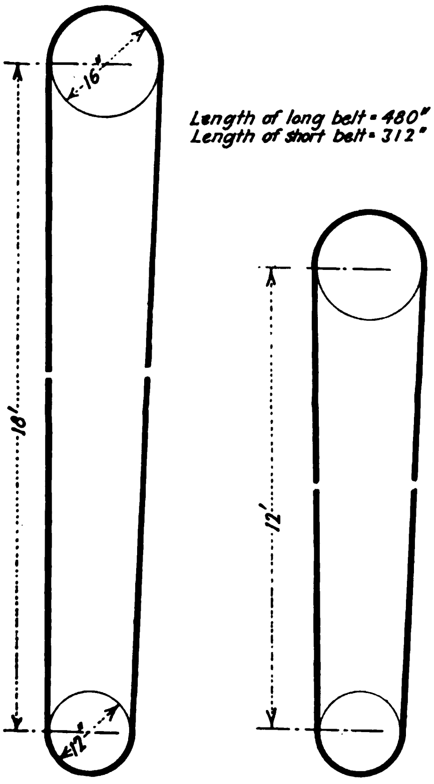


Fig. 4—Trouble with vertical drives increases with longer center distances.

On these two drives a total stretch of 5 per cent would mean an elongation of 24 in. in the belt at the left and 15 in. in the belt at the right. If the belt is shortened but 3 in. at a time the long-center drive would require cutting eight times against five for the shorter drive, or an increase of 60 per cent in the necessary maintenance.

factory in practice. These apply more particularly to countershaft and mainshaft drives. When it is not possible to obtain the proper arc of contact it is always practicable to increase the width of the belt (providing the pulleys will permit it), or a heavier belt can be used. Either of these methods will compensate for the loss in ability to transmit power.

The effect of misalignment of the pulley is not so readily noticed in drives with moderate centers as in the case of drives with short centers. When using longer centers the crown of the pulley has a better opportunity to correct misalignment in the drive. This, however, should not be accepted as an excuse for permitting pulleys to be out of alignment.

Drives with moderate or long centers are always objectionable where the pulley diameters are extremely small or where they operate in a horizontal position with the slack side of the belt on top. This condition often applies to belts driving a blower or fan. Fig. 2 illustrates what happens when comparatively small pulleys are placed on long center distances with the tight side of the belt below. It is interesting to note that a sag of 4 in. in the slack side of the belt represents an elongation or stretch of only 3.8 in. or approximately 1 per cent of the total belt length. With a sag of slightly over 5 in. (the diameter of the smaller pulley) the slack side of the belt would rub on the tight side and necessitate shortening. This would have to be repeated each time the belt elongated under load a little over 1 per cent of its length.

The two lower sketches in Fig. 2 show better arrangements. Shortening the center distance to approximately half, if this is possible, gives a most satisfactory arrangement. In this case a sag of 4 in. in the top or loose strand of the belt represents 8.3 in. elongation, or approximately 4 per cent of the belt length. The belt could, therefore, run considerably longer before it would be necessary to cut and shorten it.

When it is not possible to change the center distance, but the drive can be changed to put the slack side on the bottom, as is done in the lower sketch of the three in Fig. 2, the amount of stretch or sag in the belt does not interfere with the operation of the drive. In fact, the weight of the long belt assists in maintaining adhesion to the pulley surfaces.

For high-speed belts, where the load is variable, shorter centers are more suitable than long centers. With the short centers the flapping of the loose strand of the belt, which may result from any unevenness of the load, is markedly decreased. This is well illustrated in Fig. 3. The belts shown in solid lines indicate the decrease in the wave which results from shortening the center distance. Very short center distances, as in the belt installation shown dotted in the upper sketch of Fig. 3, practically eliminate the slack and consequent waves but decrease the arc of contact and require higher belt tensions. These objections may be overcome by the use of gravity idlers, as shown by the dotted lines in the lower sketch of Fig. 3.

In the case of a hot-saw belt, or an edger drive, the load goes off quickly as the saw cuts through the material and these belts often ride back and forth across the pulley face before they have an opportunity to contract and center themselves again. This condition is more pronounced with long center distances. Where the load is steady a belt may operate up to 5,000 f.p.m. with any reasonable center distance without giving much trouble. It is on those drives where the speed is excessive and the load variable that serious operating troubles are encountered.

This discussion, so far, has covered only horizontal belt drives. Practically the same considerations, however, apply to inclined drives where the angle of inclination is not over 45 deg. Also, as the angle of the belt approaches the vertical the operating difficulties increase, because as it stretches the belt tends to hang away from the lower pulley. This operating condition will be discussed in more detail in another article of this series.

A vertical drive laid out with long centers invariably causes trouble because of the necessity of frequent take-ups. A short center cuts down the percentage of stretch in the belt in proportion to the decrease in the length of the belt. The number of take-ups, therefore, are much less frequent for the short-center drive. This is well illustrated in Fig. 4. In this case the drive at the left has a center distance 1½ times as long as the shorter drive at the right. The comparative belt lengths are 480 in. and 312 in. respectively. A total stretch of 5 per cent over a long period of service would mean an elongation of 24 in. in the longer belt and 15.6 in. in the shorter one.

With vertical drives the belt must be shortened frequently to maintain the proper tension and adhesion on the lower pulley. Assuming that 3 in. are cut out at each shortening, the long belt will require eight cuttings against five for the shorter belt, or 60 per cent more servicing; therefore, some allowance must be made for the long centers when comparing the amount of stretch and servicing of two vertical belts.

When it is necessary to use long centers on vertical drives, it is always advisable to allow ample width in the belt, which permits decreasing the necessary tension and so results in less stretch. This, in turn, permits the belt to operate longer before it is necessary to shorten it. The diameter of the pulleys also affects the power transmitting capacity of the belt under these conditions, but the discussion of this factor is also reserved for a later article. The use and proper positioning of flexible and fixed idlers will be discussed in the next article of this series, to appear in an early issue.

Departmental Metering Practice

(Continued from page 200)

rear of a panel and be attached by studs to the test terminals and fuses mounted on the face of the panel, or potential studs and binding post may be mounted on the face of the panel with the fuses on the rear.

The insulated spring jaws of universal battery test clips on the ends of the potential test leads grip the fuse terminals and make a good connection without loosening any parts. Assuming that normal load exists at the time and that the power factor of the load is above 50 per cent, the rotating standard should be tested for correct rotation on each element of the service meter by alternately disconnecting a potential lead from each element. Disconnect the lower ± lead on one side and replace it after noting the direction of rotation; then disconnect the lower ± lead on the other side for a similar observation. If the rotation is correct on both elements, proceed with the test; if it is not correct, reverse the current lead on the side showing reversed rotation, being careful, however, to close the test link so as to bypass the standard meter.

In testing the service meter, the revolutions made by its disk in a period of about one minute are counted and compared with the number made by the rotating standard. For this purpose the large pointer of the rotating standard should be set at zero and the reading of the smaller dial recorded. Snap the potential switch when the black mark on the service meter disk passes the glass window in the case, or some fixed point if the case is removed, and again snap the potential switch when the disk passes the window or its fixed point after making the desired number of revolutions. From the data recorded, the accuracy of the service meter in per cent can be determined by the following formula:

$$\text{Accuracy of meter} = [(R_s \times K_s) \div (R_w \times K_w)] \times 100$$

where

K_s = Watthour constant of service meter.

R_s = Revolutions of service meter.

R_w = Revolutions of portable standard meter.

K_w = Watthour constant of portable standard meter.

For example, in Fig. 4 the meter test record card for No. 3 generator, date line 1-20-'26, indicates that the service meter while under test made 9 revolutions to 9.20 revolutions made by the standard. This General Electric service meter has a watthour constant of ⅓ and the Westinghouse standard used has the same constant; therefore, according to the formula the accuracy of the meter is, $(9.0 \div 9.20) \times 100 = 97.8$ per cent. In other words, the service meter was found to be 2.2 per cent slow. When necessary, it is customary to adjust the magnets of both elements an equal amount, if possible, and leave the meter as nearly correct as it can be made. The meter is called correct if its accuracy is found to be within 0.5 per cent on five repeated checks after adjustment. In case the service meter constant is different from the constant of the standard, its correct value may be secured from tables provided by the manufacturer.

The calculation of meter constants seems to puzzle many of us, although it is simple enough after all. If a 5-amp. meter is connected in the secondary circuit of 500/5-amp. current transformers, the transformer ratio is 100:1. Simply multiply the meter constant on the dial by 100, to obtain the new meter constant which must be used for the correct registration of power consumed. When potential transformers are used in connection with current transformers the new constant will be the product of the transformer ratios and the dial constant. Fig. 7 shows the method of connection when it is necessary to use instrument transformers.

The training of metermen has been given careful attention by the National Electric Light Association and different manufacturers, and many state universities and other schools have co-operated and established short courses covering this subject. Several excellent books have been published covering meter testing, in addition to a number of handbooks and bulletins that have been put out on this subject.

Functions of Control

in the Operation of Electric Motors

By H. D. JAMES
Consulting Control Engineer, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

IN THE previous article of this series, which appeared in the March issue, it was pointed out that the controller is an essential part of every drive that uses an electric motor to convert electrical energy into mechanical work. The controller regulates the power applied to the motor; it also modifies the characteristics of the motor so that the rotation is in the proper direction and the necessary speed adjustment is obtained.

In brief, the controller is to the motor what the valve gear and the throttle are to the steam engine, but the controller is more flexible and has a wider range of application than the valve gear, as it controls both the acceleration and the retardation of the motor. The speed of a steam engine depends upon the load, and its performance is somewhat similar to that of the series direct-current motor, but we have no analogy between the adjustable-speed motor and any engine.

Function of Control in Starting an Electric Motor

Electric power is usually delivered to the user at a constant potential and frequency. The direct-current motor is sensitive to the voltage applied to its terminals, as this must not exceed the counter-emf. by more than a few volts. In starting such a motor it is, therefore, necessary to reduce the voltage applied to the terminals of the motor by means of a controller. The customary method of reducing the voltage is to pass the current through a resistor which converts most of the electrical energy into heat, leaving only a relatively small voltage at the motor terminals to produce the torque necessary to start the load. As the motor accelerates, it generates a counter-emf. so that the voltage at its terminals must be gradually increased by reducing the resistance in series with the motor. When full speed is reached, all of the resistance is eliminated.

A manual controller may be used and the rate of short-circuiting the resistor left entirely to the judgment of the operator. This may be desirable as most motors can withstand overloads for short periods of time; therefore, a too-rapid short-circuiting of the resistor usually causes no harm although it may place an undesirable strain on the equipment. The most common forms of manual control are the faceplate starter and the drum controller.

Where magnet contactors are used and controlled by a master switch, the short-circuiting of the starting resistor can be made automatic. This means of acceleration is usually provided with magnetic control so that the only function of the operator is to initiate starting. Where speed control is one of the functions, the push-button station is usually replaced by a master switch having several positions corresponding to the speeds required. There are three common methods of acceleration: namely, time delay, counter-emf., and current limit. Sometimes a combination of these is used.

The alternating-current motor is not so sensitive as the direct-current motor to the voltage applied at the time of starting. The smaller sizes of squirrel-cage motors are frequently started by connecting to full voltage. The wound-secondary induction motor has external resistance connected in the rotor circuit during the starting period. These latter motors perform very similar to a direct-current series motor, torque being in proportion to the current.

THIS is the second article of a series in which Mr. James is discussing the functions of control equipment in the operation of electric motors, and describing the construction and operating principles of the types of such equipment in industrial use. The first article appeared in the March issue and dealt with the general application of control equipment. The third article of this series will appear in an early issue.

The direct-current motor can be converted into a generator to assist in retarding the load. The usual method of accomplishing this is to connect the brushes of the motor through a resistor, and is known as "dynamic braking." A dynamic braking controller, with the connection diagram, is shown in Figs. 1 and 2. If the motor is shunt wound, the field must remain excited; if self-excitation is used, the braking effect decreases very rapidly with the speed. Series motors must have their field windings reversed.

How Control Functions in Stopping a Motor

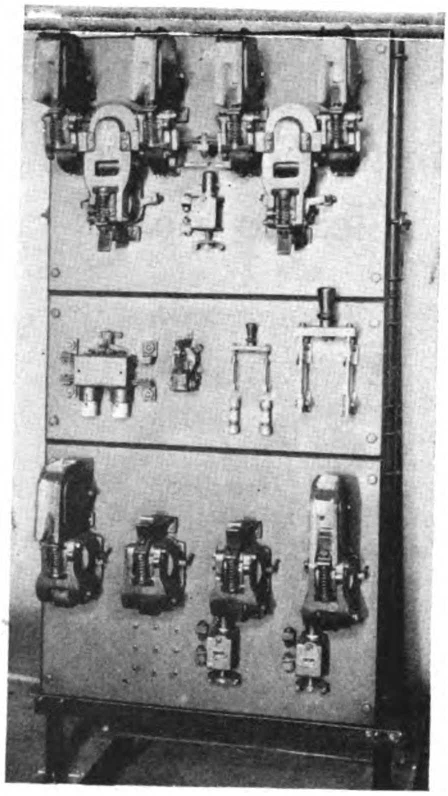
Dynamic braking may be obtained by providing the reverse switches with back contacts, so that when both switches are opened, they complete the circuit through the braking resistor. Sometimes it is desirable to short-circuit portions of this resistor during slowdown, but this is not ordinarily required as the friction load is sufficient to stop the motor after the speed is reduced.

Another form of braking is obtained by increasing the internal or counter-emf. of the motor, so that it is above the line voltage. This causes the motor to operate as a generator, returning power to the line, and is known as "regeneration." Shunt motors having an adjustable field strength will very readily regenerate when changing from a higher to a lower speed. This regeneration may be so violent as to cause damage if it is not regulated.

The writer recalls several instances in which shunt motors were connected to overhauling loads. In lowering a load, the motor was driven considerably above its nor-

Fig. 1—This controller stops the motor by the application of dynamic braking.

The connections for this controller are shown in Fig. 2. On the top panel are the forward and reverse magnet contactors, marked *1* and *2*, *3* and *4*, respectively, in Fig. 2. These contactors are mechanically interlocked and operate the current-limit relay which controls the closing of the first accelerating switch. When both reversing contactors are opened the dynamic braking circuit is completed through the bottom contacts (*1A* and *4A* in Fig. 2) which are held closed by the bottom coils until the motor is brought to rest. These coils are either in series with the dynamic braking circuit, as shown in Fig. 2, or shunt coils may be used and connected across the motor terminals. On the bottom panel at the left is the line contactor shown as *5* in Fig. 2. On the right-hand side of this panel is the first accelerating contactor, *11*. The current-limit relay under this contactor controls the adjacent accelerating contactor, *12*. Its relay in turn controls the last accelerating contactor, *13*. On the center panel are located the main line knife switch, control circuit switch and fuses, low-voltage relay, and two-pole overload relay.



mal speed with a weak field; then the field was abruptly increased to its maximum value. A 500-volt motor operated in this way developed over 1,500 volts across the brushes which resulted in flashing and insulation troubles. Series motors operating cranes sometimes have a severe dynamic braking applied by the limit stop. If the motor enters this limit stop, running light, it may generate an abnormal voltage when the dynamic brake is applied.

Regeneration with series motors is used for railway applications and presents many interesting problems. The motors are usually grouped in series-parallel combinations, which give considerable flexibility for regenerative connections.

If a direct-current shunt motor or an alternating-current induction motor is operating at full speed and the line voltage is abruptly decreased, the motor regenerates and reverses its torque. This drop in voltage may be caused by starting another motor, or the dip may be the result of a line disturbance. The reversal of torque is sometimes objectionable, particularly if the motor is connected to the load by means of a chain, as this type of drive has considerable lost motion. Gear drives "knock" at such times, due to the lost motion of the gearing and some of the gear teeth may be broken. If the motor is belted to the load the reversal of torque may throw the belt off the pulley. The effect of the voltage drop depends very much on its magnitude and the abruptness of the drop.

Alternating-current induction motors wound for different pole combinations regenerate when the combination is changed to give a lower speed, as the motor then operates above synchronism during the retarding period. This type of motor should be applied to the load with care or else the controller so arranged that the motor circuit remains open until the speed has been reduced to the normal value for the pole combination used. Some applications do not require operation at reduced speed until after the machine has been stopped. Direct-current motors operating from two or more voltages regenerate when changed to a lower voltage, so that the controller must provide current-limiting means during the transition period.

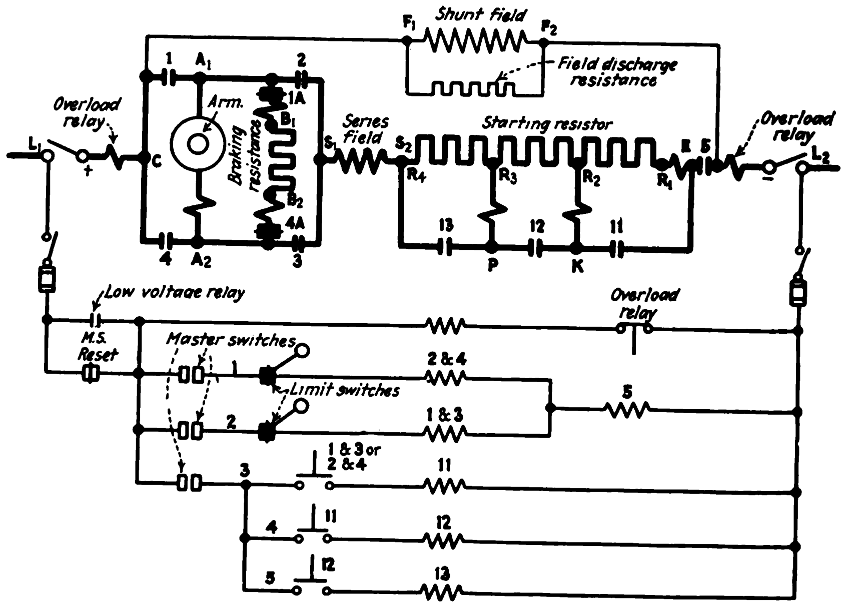
A friction brake is often used to assist in stopping the load and is particularly desirable in cases where the load will overhaul, as on hoists. Here the brake not only assists in stopping the load, but also holds it in a fixed position until power is applied to the motor. The friction brake is usually applied by springs and released by a magnet and is, therefore, commonly called a magnet brake. On large mine hoists oil or air pressure is used for applying the friction brake, in order to make possible easy adjustment of the friction load.

When magnet brakes are used with direct-current motors, the magnets are usually connected in series with the motor armature, although some applications require a shunt brake. Alternating-current magnet brakes are always shunt wound, as the impedance of the brake circuit prevents it being used in series with the motor.

Reversing the Direction of Rotation

When a motor is started from rest, the normal voltage is impressed on the starting resistance. If, however, the motor is operating at full speed and the armature connections are reversed, the counter-emf. is added to the line voltage, so that more resistance is required to limit the current to the same value as when starting from rest. It is usually assumed that the total volt-

Fig. 2—Diagram of connections for dynamic braking controller shown in Fig. 1.



age at such a time is approximately double the line voltage.

Controllers that permit the motor to be reversed at full speed are called plugging controllers. A controller of this type is shown in Figs. 3 and 4. One section of resistance is provided, which is automatically short-circuited at once when the motor is started from rest. If, however, the motor is running this section of resistance is kept in circuit automatically until the armature is approximately at zero speed. This section of resistance is usually known as plugging resistance, and has an ohmic value approximately equal to the starting resistance. Control of this type is commonly used on the table rolls in steel mills, but may be used for any application which requires this type of control. Some reversing planer control is of the plugging type.

If dynamic braking is used for stopping the motor, the coils of the dynamic braking contactors are usually connected in the circuit so that their contacts remain closed until the motor is at zero speed. This automatically prevents the reverse switches from being closed while the motor is still generating counter-emf., and prevents the motor from being plugged.

Control of this type is very common, not only in steel mills, but for reversing planers, elevators, hoists and other applications. Many engineers believe that it is easier on the equipment and, therefore, preferable to the plugging control where the rapidity of operation will permit its use.

Plugging control is required where the motor is started very rapidly

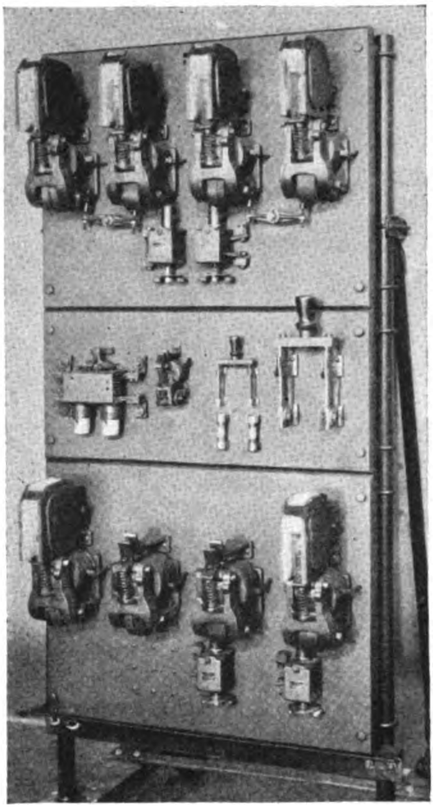


Fig. 3—This is a plugging controller used when rapid reversal of a motor is necessary.

The connections for this controller are shown in Fig. 4. The four contactors at the top of the board (*1*, *2*, *3*, and *4*, in Fig. 4) make the reversing connections; two contactors are closed for each direction of rotation. Current-limit relays are shown underneath two of the contactors. These relays control the first accelerating contactor, *11* in Fig. 4. On the bottom panel are four contactors. The one at the left is a line switch, shown as *5* in Fig. 4. The contactor at the right, *11*, short-circuits the plugging resistance. The relay under this contactor controls the next accelerating contactor, *12*. The relay under contactor *12* controls contactor *13*, which completes the acceleration. On the center panel are the main line knife switch, the control circuit knife switch and fuses, the low-voltage relay, and the two-pole overload relay.

either in the same or in the reverse direction.

The plugging of a motor using manual control, causes severe arcing on the controller, and usually is not necessary for proper handling of the machine. Manual controllers do not provide automatic means for retarding the short-circuiting of the control resistor and, therefore, careless handling often places abnormal strains on the equipment. These controllers may be protected by a contactor and instantaneous overload device, which will disconnect the motor from the line when the controller is improperly handled.

Adjusting the Speed of the Motor

Many applications require the motor to operate at different speeds. There are two general types of speed control: one having a speed which varies with the load; the other a definite speed independent of the load.

If a direct-current, series-wound motor has resistance connected in the armature circuit, the speed of the motor will depend upon the amount of resistance in circuit and also upon the load. The performance is very similar to that of a steam engine, the controller taking the place of the throttle valve. The speed of the steam engine will depend upon the load and the opening of the throttle valve, if the governor is disconnected. If it is desired to hold the engine speed at a fixed value, a centrifugal governor is used to regulate the amount of steam delivered to the engine.

A centrifugal governor could be provided for the series motor to regulate the amount of resistance in the circuit so as to maintain the speed at a constant value independent of the load, but this is not necessary as the shunt-wound direct current motor is used where constant speed is required. The wound secondary induction motor with resistances in the secondary circuit controls in a similar manner to the direct-current series motor, the controller being used for changing the resistance, to change the speed.

The direct-current shunt motor can have its speed adjusted by changing the strength of the shunt field. The control of this motor is similar to a mechanical drive con-

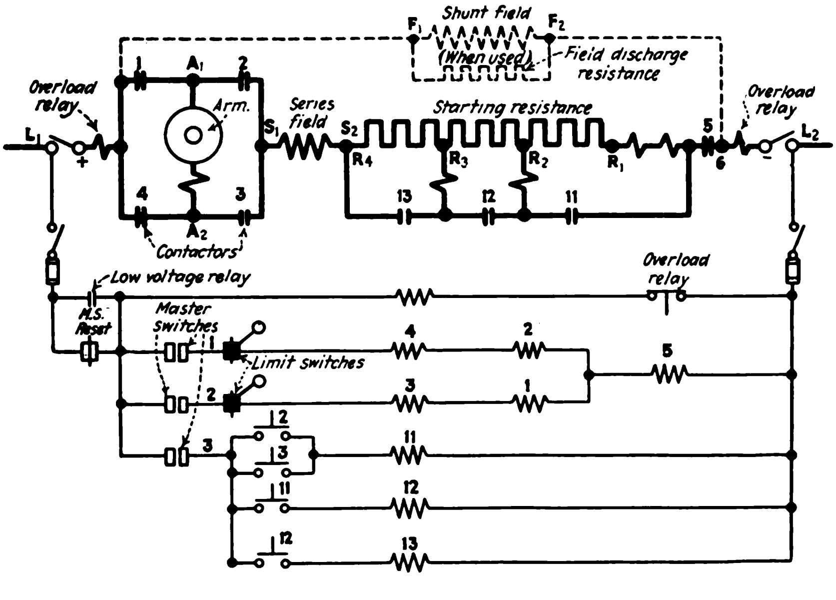


Fig. 4—Diagram of connections for plugging controller shown in Fig. 3.

sisting of two cone pulleys connected by a belt. The speed at which the load is driven is changed by shifting the belt. This speed remains constant, independent of the load, providing the power driving one pulley maintains a constant speed.

The shunt motor runs at a constant speed, independent of the load, providing the line voltage remains constant. There is a slight change in speed with a change in temperature and also with a change in load, but this variation is small and is very similar to the belt slippage that would occur on the cone pulley drive, due to a change in load. For practical purposes, it can be assumed that the speed of a shunt motor remains constant.

The speed of a direct-current shunt motor is sometimes changed by connecting it to an individual generator and varying the field excitation of the generator. This method of control is called the Variable-Voltage System. It is used quite extensively for high-speed elevators and large reversing motors in steel mills.

The polyphase induction motor operates at a constant speed depending upon the number of poles. Some motors are arranged so that the number of poles can be changed by reconnecting the windings. This change in speed is the same as changing the gear ratio on an automobile. The most common arrangement is a 2:1 speed ratio which can be obtained with a single winding by reconnecting this winding for a different number of poles. If some other speed ratio is required, it is necessary to provide two separate windings.

Some motors are arranged to operate at four different speeds. They are provided with two separate windings, and each winding is arranged so that it can be reconnected for a 2:1 speed ratio. These motors are usually provided with a squirrel-cage rotor. If they have a wound rotor, it is necessary to change the winding of the latter in a manner similar to the change in the primary or stator. Motors of this latter type are used to drive the draft fans for steam boilers.

The speed of a polyphase induction motor can also be changed by changing the frequency. In some applications where a low starting speed is necessary, a small generator is furnished to give a low frequency for operating the motors when starting. Experimental installations have been made, using a separate machine for varying the frequency to obtain different motor speeds, but such systems have not found practical applications, as the Variable-Voltage System of controlling direct-current motors is simpler and no more expensive.

Provision for Sequence of Operation

In the first article, a number of examples were given of interlocking motor control to obtain the desired sequence of operation. The interlocking of control circuits is a very common feature in control systems and its application is more or less obvious. Thus, the doors on an electric elevator are interlocked with the control circuit so that the elevator cannot be started until the hatchway door and car gate have been closed. This is an interlocking device for the protection of persons. Again, a manual controller provided with circuit breaker protection may be so interlocked that the circuit breaker cannot be closed except when the controller is in its initial position. An interlock of this kind is for the purpose of protecting the equipment against abnormal starting conditions. Many illustrations of interlocking could be given, but its function is so easily understood that further examples are not necessary.

Necessity for Overload Protection

All controllers should provide some form of overload protection, not only to protect the electrical machinery from burning out, but also to protect the devices which are driven by the motor from mechanical injury. Overload devices may be divided into three groups:

(*1*) To afford protection against continuous overload.

(*2*) To afford protection against abnormal loads of short duration.

(*3*) To afford protection against short-circuits.

Protection against continuous overloads is not difficult to obtain, if the motor is operating on a steady load. The control can be arranged to short-circuit the overload protection during the starting period, so that a device having a short time element will serve the purpose. Motors operating on intermittent loads, such as cranes or hoists, machine tools, or other application where such loads occur are difficult to protect against continuous overloads, as it is necessary to provide an overload device that will not respond to the momentary overloads, but will disconnect the equipment when the load has overheated any part of the equipment, due to an unusually rapid cycle of operation, or to other causes.

Overload relays of the thermal type have been developed for this purpose, but so far the commercial relays provide this protection only for a steady heating of the electrical equipment, and other devices must be used to provide protection against short-circuits. Many of the dashpot-type relays and some other types have a sufficient short-time element to afford protection against abnormal overloads, and will operate before the fuse is melted. The amount of overload which the controller will handle is, of course, limited, depending upon the size of the controller, but in practice, it has been found that it will take care of abnormal loads that are not sufficient to melt the fuse protecting the feeder.

A fuse is the means that is usually relied upon to afford short-circuit protection. The Code requires all circuits and feeders to be protected (usually with fuses) so that the fuse back of the controller affords circuit protection to the electrical equipment, and prevents this equipment being destroyed by the ordinary short-circuit.

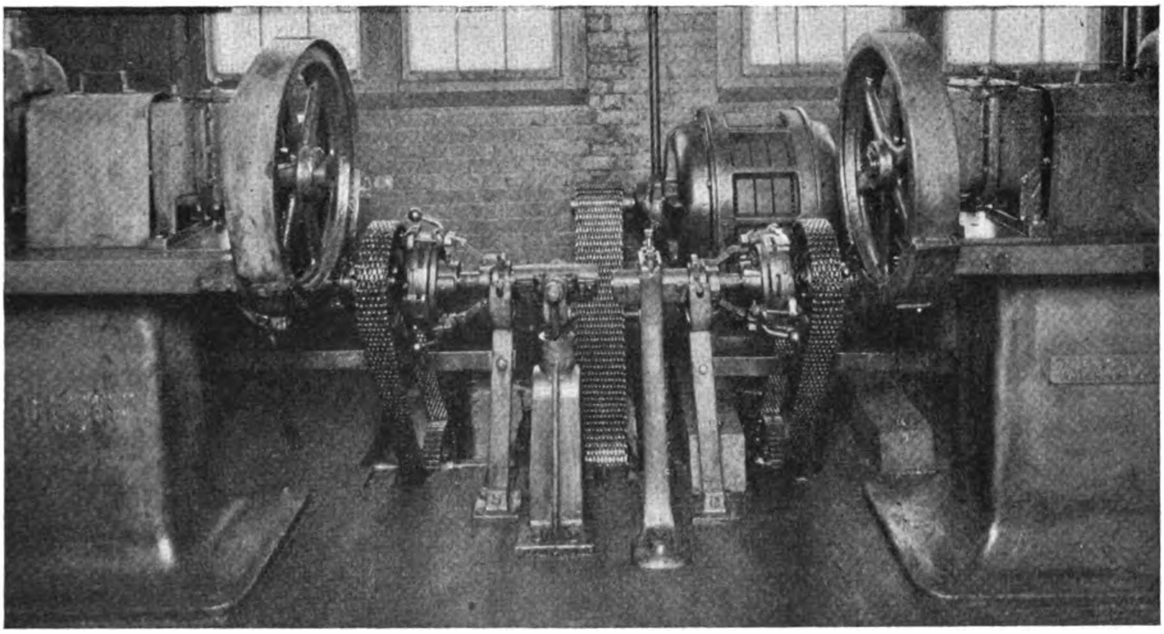
In most installations there is a considerable length of wire between the controller and the transformer, or generator, so that the impedance of the circuit is sufficient to limit the severity of a short-circuit. Where motor and control equipment is located close to a large source of power, such as may occur in a central station, additional precautions may be necessary to protect against short-circuit conditions.

If the line voltage fails, it is necessary to return the controller automatically to its initial starting position, so that the motor can be accelerated in the normal manner when power is again available. Two general types of devices are used for this purpose:

(*1*) Low-voltage release. This permits the motor to start automatically upon restoration of power. Pumps and air compressors are common applications for this type of protection.

(*2*) Low-voltage protection. This device prevents the motor restarting on restoration of power until the

(*Please turn to page 215*)



Here the motor drives the lineshaft beneath the floor through a Whitney silent chain. Each machine is driven from the lineshaft through a jackshaft with a clutch by a smaller Whitney chain.

Motor drives through

Worm Speed Reducers, Chains and Variable-Speed Transmissions

By GORDON FOX

Electrical Engineer,
Freyn Engineering Co., Chicago, Ill.

INCREASING use of high-speed motors has brought up the problem of connecting the motor to its driven machine or other load with an intervening speed-reduction device to obtain the proper operating speed. Previous articles in this series have discussed problems encountered with a motor drive through flexible couplings and clutches, where the connection is made without speed reduction, and also with belts, gears and speed reducers, which are used where a change in speed is desired. This article will discuss similar considerations involved in connecting a motor to its load through worm-gear reduction units, variable- or adjustable-speed transformers, and chain drives.

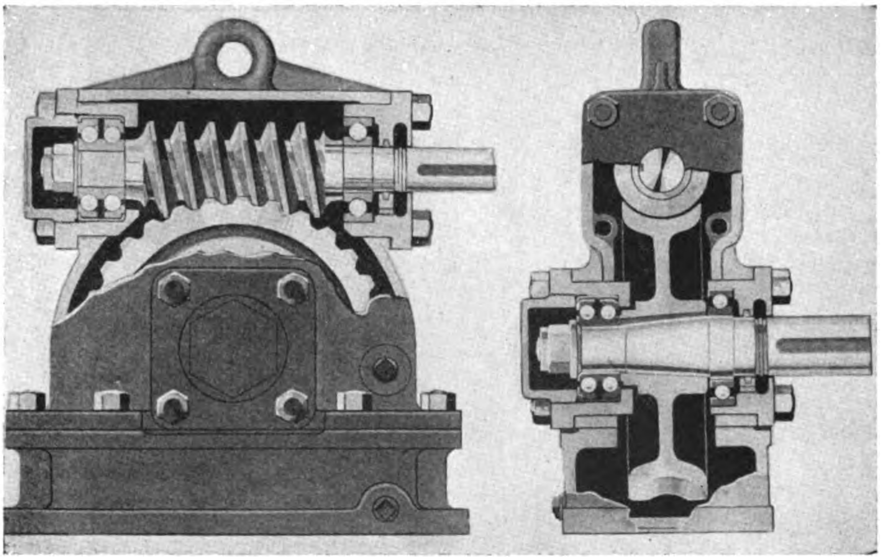
Worm gears are extensively used for motor-drive speed reductions. Sometimes they are a part of the driven machine but more commonly they take the form of a speed-reduction unit intermediate between the motor and drive. This type of unit is available over a wide range of sizes from fractional horsepowers up to 500 hp. Standard, single-reduction units afford ratios from about 5:1 up to 100:1. Double-reduction units afford ratios up to several thousand to one. Although worm gears are extensively used for low ratios, they are particularly advantageous for high ratios because of their relative simplicity.

Worm gear units are positive, quiet, and free from vibration. The driven shaft is at an angle of 90 deg. with the driving shaft. It is preferable that the worm mesh with the bottom of the gear, running in oil, which is thrown from the gear by centrifugal force into bearing troughs. If the worm is located above the gear it is more difficult to lubricate satisfactorily. Pressure lubrication, provided through the use of a small rotary pump and oil-circulating system, is particularly desirable for this construction, especially if the wormwheel speed is high, because in such a case the oil carried up by the wheel, will be thrown off by centrifugal force before reaching the worm.

The worm produces an end thrust, requiring ample and well-adjusted, end-thrust bearings. Ball and roller bearings are frequently used, not only for thrust but also for radial load. A flexible coupling should be interposed to protect the motor from possible end thrust. It is desirable to mount the motor and the worm-gear unit on a common bedplate, where possible.

The best running surface speed for ordinary worm gears is about 300 to 500 f.p.m. The highest grades of modern wormwheel units are operated with running speeds of 2,000 f.p.m. and above. For such service the worm must be precision ground to secure uniformly distributed pressure and must be heat-treated to give a very hard surface with a low co-efficient of friction.

Worms with a helix angle less than about 10 to 12 deg. are not reversible



A complete ball-bearing installation on an Albaugh-Dover worm-gear speed reducer.

but are self-locking, in that the wheel will not drive the worm. Sometimes they can be used in a holding or self-braking capacity due to this feature. This relation is true only when the worm and wheel are at rest. 'When in motion it is entirely possible for the wheel to drive the worm without locking. This is due to the lower co-efficient of friction when running as compared with the co-efficient at rest. Thus it is possible for a motor to serve in a braking capacity against an overhauling load even with a worm drive of 10 to 12 deg. helix angle.

Reduction units for high ratios use single-thread worms of low helix angle, whereas gears for low ratios use worms with two or more threads and having a greater helix angle. Good efficiencies are obtained when the helix angle is above 25 deg. Worms with low helix angles have low efficiency because of the large proportion of sliding effect to rolling effect.

Efficiencies of worm gears are subject to wide variation, being dependent primarily upon the helix angle, the materials of which the worm and wheel are made, and particularly the kind, condition, and effectiveness of the lubricant.

During the last few years many manufacturers of worm gears have redesigned their equipment, adding ball or roller bearings, providing better facilities for lubrication, and using special alloys in both worm and worm gears. The worms are frequently heat-treated and ground. Special bronze or other alloys are used for the gear.

Units having helix angles above 25 deg. may have efficiencies ranging between 85 and 95 per cent. Self-locking units may have efficiencies between 65 and 80 per cent under load. The initial efficiency is well maintained over the life of the gearing. Units with low helix angles may require rather high starting torques because of the high static friction.

The horsepower ratings of commercial worm-gear reducers are nominal and are generally based on steady, uniform loads with little shock. The selection of a proper unit for a given application requires consideration of such factors as shock, peak loads, continuity of service, vibration, sudden starting and stopping, reversal, overhauling loads, type of motor, and prevailing load. Manufacturers' ratings must be discounted according to the service conditions. For very severe conditions it is necessary to select a unit rated at double the horsepower of the motor.

Temperature is often a limitation. Many worm-gear units are constructed with liberal oil reservoirs and enclosing cases to provide ample radiating area. However, for units of large horsepower rating, or for high ratios of lower efficiency, or where service is continuous, water-cooled housings may be necessary.

The oil level is important in any kind of speed reducer. If it is too low the lubrication may be unsatisfactory but if it is too high, churning of the oil may lead to heating.

For extremely high-reduction ratios a worm- and a spur-gear reducer are frequently connected in series. Reductions of 50,000: 1 have been obtained in this manner. Either the worm or the spur-gear reducer may be connected to the motor to drive the other reducer. These high reductions are commonly used on slow-speed conveyor drives, such as assembly conveyors.

The single-reduction worm unit is always a right-angle drive and so permits mounting the motor and the reducer alongside the machine it drives, thus conserving floor space. Practically all manufacturers will provide worm reducers with the worm either above or below its gear, or for vertical drives with the low-speed shaft extending either up or down.

Chain drives are also widely used for obtaining speed reductions. Both the roller and the so-called silent types of chain are well suited for many motor drive applications. Chain drives are positive, with a fixed ratio similar to a gear drive. Because of the positive action without any slippage or give, breaking or safety elements are necessary to protect the motor and chain wherever there is a possibility of sudden stoppage. Also, vibrations and shock loads require especial consideration with motor drives because of the limited flexibility of the chain. In the case of such loads the user will find it advisable to consult with the chain manufacturers.

An important advantage of chain drives is that the motor and driven shaft can be located on short centers, although a chain drive permits of greater leeway than gearing as to center-line distance and motor location. Chains are quiet in operation, due to the fact that the links have no sliding action on or off the teeth, and that the power is transmitted by all the teeth in the arc of contact. Such drives are reliable and are not subject to sudden failure. The operating efficiency is about 96 to 98 per cent and this efficiency is maintained throughout the life of the drive. Where necessary, in special cases, a chain drive permits of a change of ratio by a change of sprockets. Because no initial tension is required in the chain, the side and pull on the motor shaft is, largely confined to that produced by the transmission of power.

Roller chains may be used on drives operating up to 3,600 r.p.m. Silent chain drives have been used to transmit up to 5,000 hp., and on small units for speeds up to 5,000 f.p.m. The larger drives operate at relatively low rotative speeds and

use chains of large pitch; the high-speed drives are confined to lower powers, transmitted by chains of small pitch. There is a fairly definite limit to rotative speed for chains of each pitch and these limiting values can be obtained from the various manufacturers. When these limits are exceeded the drives become noisy and wear is more rapid. The rotative speed and diameter of the sprockets, rather than the linear speed, are the limiting considerations; a higher linear speed is permissible with a large sprocket than with a small sprocket.

The highest advisable speed ratio is 6:1 for large powers and 8:1 for small powers, although ratios of 10:1 and higher have been used successfully for drives where moderate chain speeds are employed. The minimum number of teeth in the pinions or smaller sprockets is rather definitely fixed according to the pitch of the chains. Thus, increased reduction ratios must be obtained by increasing the number of teeth in the larger sprocket. However, the more sprocket teeth in contact with the chain the less is the allowable wear on the joints before the chain will climb over the sprocket teeth. The life of the drive is more or less in inverse ratio to the reduction.

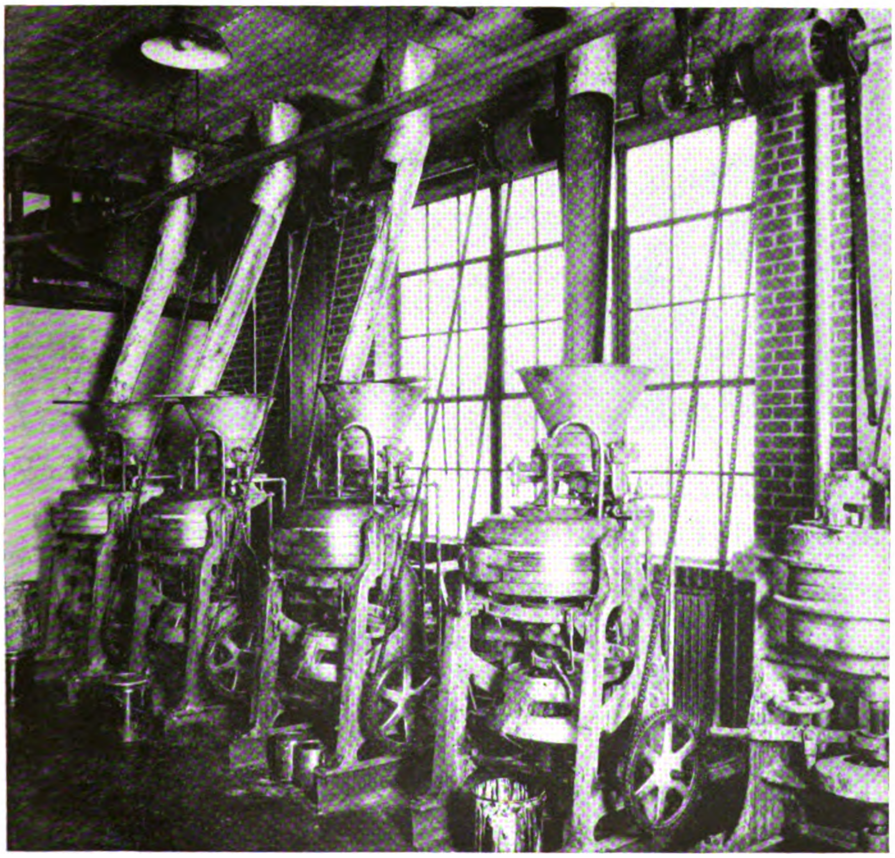
The first cost of chains is higher than for the belts or gears. Also, for safety, both to the operators and the drive, chains should be guarded. Usually a sheet-metal case is used which also serves to facilitate lubrication. Silent chain drives may be used for reversing service if the reversals are not too sudden and severe. Roller chains may also be operated in either direction.

The first factor governing the selection of a chain is the horsepower it must transmit. The value used should represent the maximum running load to be applied. Peak loads must be considered but occasional momentary peaks, except shock loads, can be handled safely as chains have an ample factor of safety. If regularly overloaded, chains will not give satisfactory service, however, due to rapid wear.

Where shocks are frequent, as with an air compressor or reciprocating pump drive, an oversized chain is recommended with an allowance of 20 to 50 per cent, according to the severity of the service. Some engineers question the use of chain drives on fluctuating loads, but there are many such successful installations. Sometimes a spring compensating sprocket is used to absorb the shock. It is generally better, however, to avoid load pulsations, where possible, through the use of sufficient flywheel effect.

A combination of silent- and roller-chain transmission is used in this paint factory.

The lineshaft is driven from a motor by a Link-Belt silent chain and each individual paint mixer is driven from the lineshaft by a long Link-Belt roller chain. Each machine is cut in or out of service by Twyncone clutches.



Manufacturers of both roller and silent chain for motor drives issue tables and other data for use in selecting the proper chain for a particular installation. When making the selection the industrial engineer frequently finds that he has an option in choice between several chains, any one of which may be rated for the load; this choice lies between chains of different pitches, with correspondingly different widths. In such cases it is generally advisable to use the wider chain with the lesser pitch, although the narrower chain of longer pitch would be cheaper.

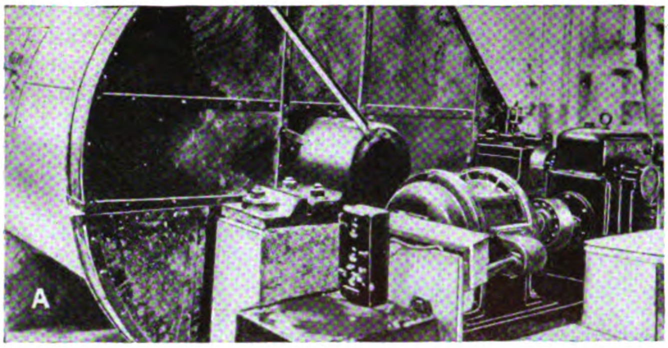
The width of the chain should preferably be from two to six times the pitch, but a range of one and five-tenths to ten times the pitch is permissible. Where very quiet operation is desired, as in an office building, wide chains of short pitch are used with 20 teeth or more in the smaller sprocket, operating at moderate linear and rotative speeds.

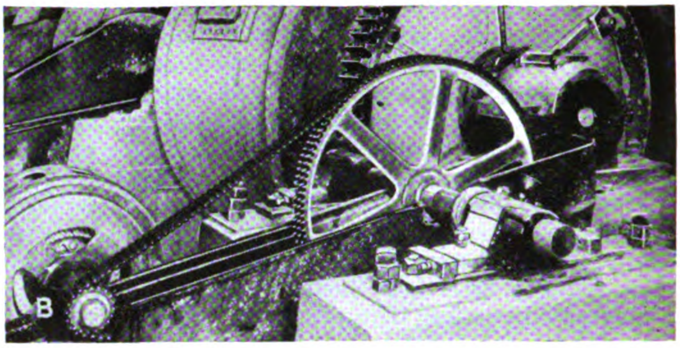
In determining the reduction ratio to be used a choice may be afforded in motor-speed rating. It may then be advisable to determine the combined cost of motor and chain drive for the different possible combinations. The lower cost of the higher-speed motor will be offset to some extent by the larger sprocket and longer chains required for the higher ratio. Such factors as motor duplication, efficiency, and power factor are usually more important than small differences in first cost; nevertheless, the possibilities for saving in first cost should not be ignored.

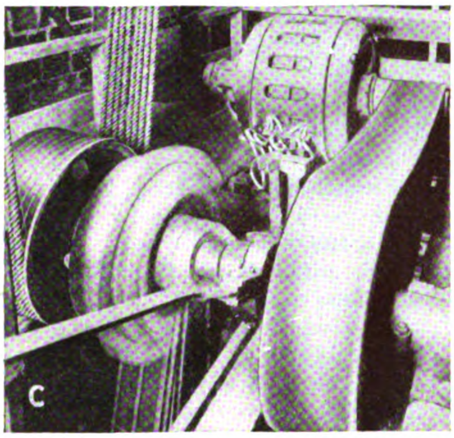
Where an exact ratio is not imperative, a slight variation may permit of a better selection of sprockets without using a sprocket with too few teeth or a chain of unsuitable pitch. Where clearances are limited, sprocket diameters must be selected accordingly.

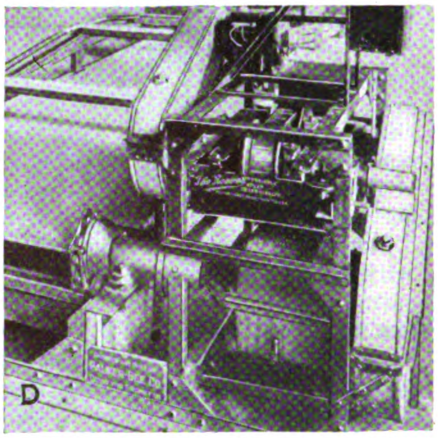
The proper selection of a chain to obtain the best possible service under a given set of conditions is a matter in which the chain manufacturers may well be consulted.

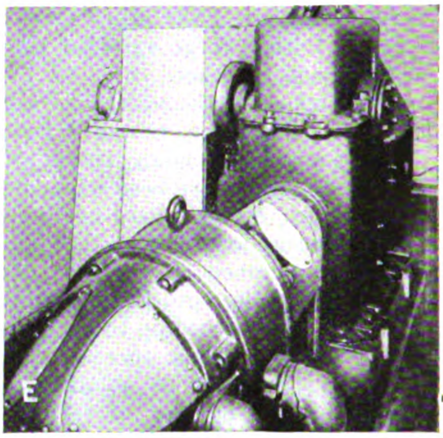
The center distance between shafts should be approximately equal to the diameter of the larger sprocket plus the radius of the smaller sprocket. This dimension may be moderately

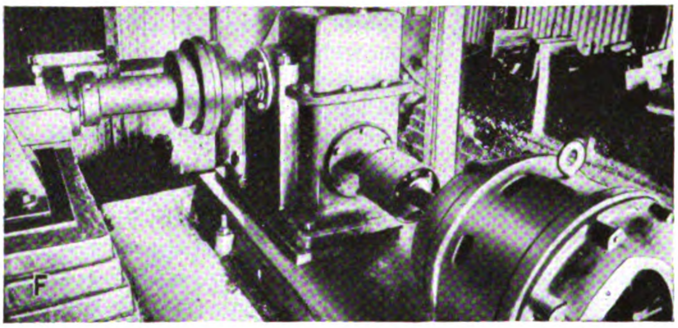


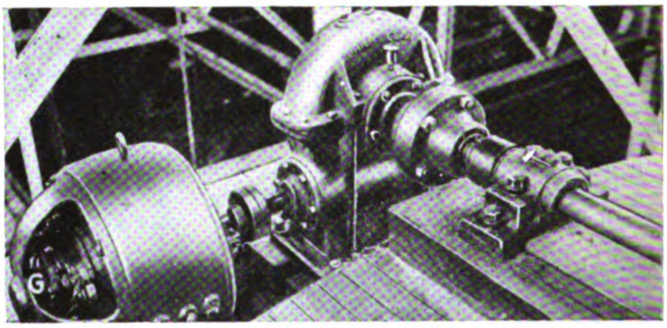


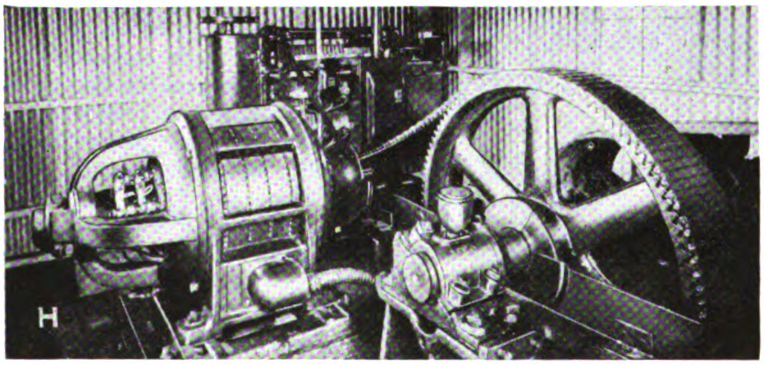


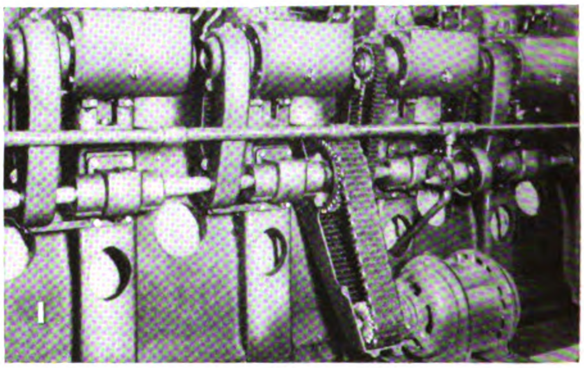












Nine Applications of Worm Reducers, Chains and Variable-Speed Transmissions

A—A compact installation of DeLaval worm speed reducers driving a pebble mill.

B—This 6-ft. Silex lime ball mill is driven at 30 r.p.m. by a 15-hp., 1,150-r.p.m. motor through a triple Diamond roller chain and a gear reduction. The chain gives a reduction from 1,150 r.p.m. to 146 r.p.m.

C—An American High Speed silent chain connected to an elevator drive operating under very dusty conditions. Here a 50-hp., 865-r.p.m. motor drives the shaft at 230 r.p.m. The center line distance in this case is 8 ft. 7 in.

D—Here an assembly conveyor in an automobile body factory is driven through a Reeves variable-speed transmission and a Palmer-Bee speed reducer. The three elements of the drive are connected by silent chains, which gives a very compact installation.

E—A 40-hp., 850-r.p.m., totally-inclosed motor drives this apron coal conveyor at a reduction ratio of 29½:1 through a Cleveland worm reduction unit.

F—Single-reduction worm gears give a right-angle drive which permits their installation alongside the equipment, as in the case of this Jones heavy-duty worm-gear reducer operating on a mine fan drive at a ratio of 8½:1.

G—This Philadelphia worm gear reducer is direct-connected to a 5-hp., 950-r.p.m. electric motor to drive a pulp agitator in a paper mill, at a reduction ratio of 35:1. Here the unit is placed out of the way and above the working floor.

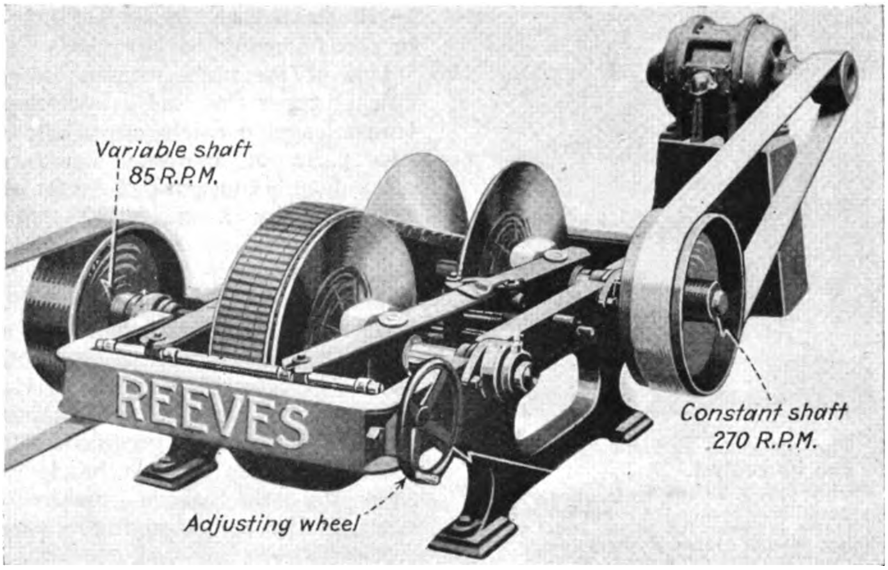
H—Link-Belt silent chain is used in connection with a variable-speed motor to drive the pumping rig countershaft at an oil well. These two shafts are mounted on 36-in. centers.

I—Morse silent chain connects the motor to this machine tool lineshaft, and six small Morse chains drive the various spindles on a gang drill. Each of these smaller chains permits the use of a shorter center distance than would be possible except with a train of gears. In this case the drive unit is mounted on the floor at the rear of the machines.

exceeded to advantage. However, with a long center distance on horizontal or slightly inclined drives, the weight of the chain tends to cause excessive tension.

Sometimes the centers on a high-speed drive are such that chain flopping synchronizes with load impulses. A small change of center distances by adding or removing links will usually correct the trouble. Chains increase in length due to wear. There should be no initial tension; neither should there be undue slack, as whipping of the chain also increases the wear. Means of adjustment are, therefore, desirable and a sliding base or rails are generally used under the motor.

Drives should preferably be horizontal or slightly inclined. Vertical drives should be avoided because they must be run rather taut and it is difficult to compensate for wear. For an inclined drive, the driving sprocket should be the upper one and the driven wheel should be flanged.



This shows the construction of the Reeves variable-speed transmission.

A constant-speed motor is connected to the input or constant-speed shaft by a belt or chain. Output of the variable-speed shaft is controlled by the adjusting wheel which shifts the relation of the cone-faced pulleys in the center to change the relative pulley diameters. In this case the pulley for the V-shaped belt on the constant speed shaft is at minimum diameter and the pulley on the variable-speed shaft is at maximum diameter which gives the minimum output speed. This is a 10:1-ratio, variable-speed drive and when the cones are shifted so that the constant speed shaft is of greatest diameter and the variable speed shaft is of least diameter, the maximum speed of 850 r.p.m. is obtained.

With ordinary horizontal or inclined drives up to 45 deg., direction of rotation may be such as to cause either the upper or lower strand to be slack. Where the centers are rather short, it is preferable to have the lower strand slack. If the slack is in the upper strand there is a greater possibility of the slack chain teeth being pushed out of proper engagement with the teeth of the driven sprocket. Drives with long centers and small sprockets should be run with the slack in the lower strand; otherwise there is danger of the slack, upper strand rubbing against the lower. With steeply-inclined drives it is generally best to have the slack in the strand having the lesser inclination.

Shafts should be level and sprockets must be in alignment and placed as close as possible to the bearings. The alignment may be checked by observing the guide links in the chain because when out of alignment, the wear on these links is not equally distributed on both sides.

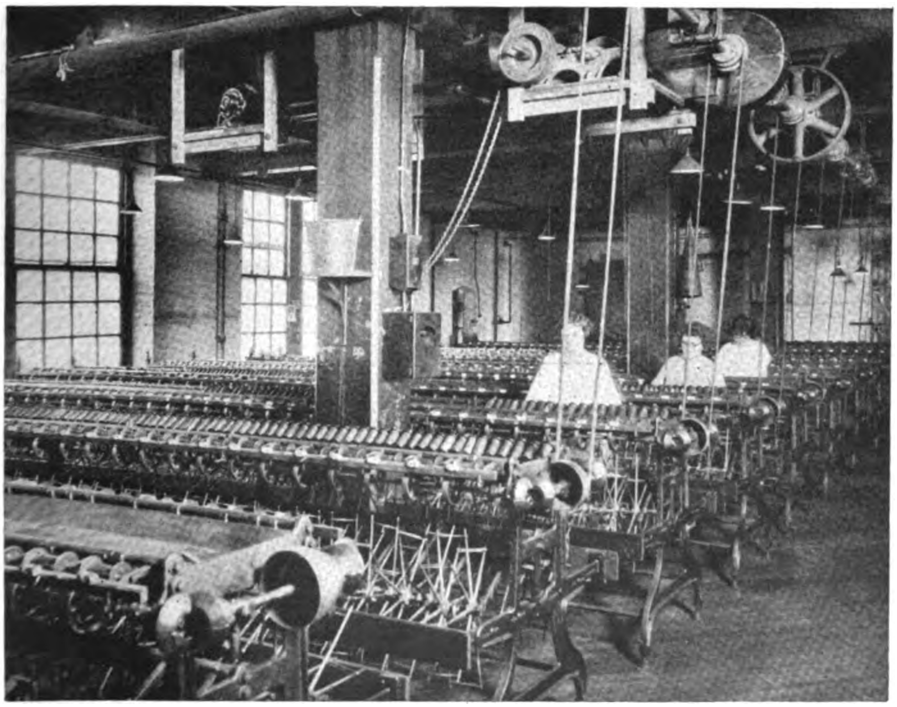
Silent chain wears at the joints. The usual life is said to be 15,000 to 20,000 hr. of operation, although this is often exceeded. Wear at the joints causes increase of chain pitch and the chain then tends to climb on the larger sprocket. Chain wear occurs primarily at the smaller sprocket and is emphasized if this sprocket is very small or the rotative speed is high.

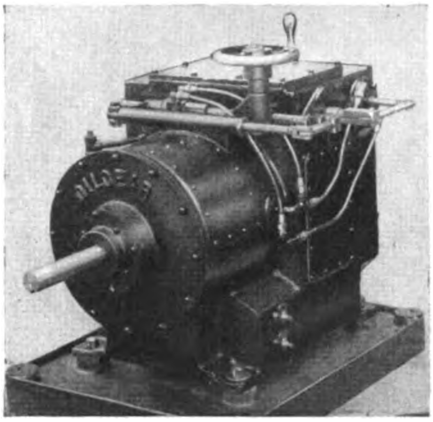
Repinning with oversized pins, where possible, compensates for the wear in the links and brings the chain back to normal pitch. The cost of repinning is about 20 per cent of the cost of a new chain. The life of a repinned chain is estimated to be about 75 per cent of that of a new chain. Sprocket wear is usually small if the teeth are properly cut because the tooth pressure is distributed over a number of teeth.

Ordinarily the small sprockets are made of hardened steel and the large

An application of the Lewellen variable-speed transmission in a silk mill.

Here the motor is belted to the variable-speed transmission which in turn drives the lineshaft through a silent chain. In this instance the transmission is used for slowing down the silk throwing and winding frames when stopping, and for gradually bringing the frames up to the running speed when starting. When the operation is started at full speed, usually about 75 per cent of the fibers break and the operators lose from 1 to 3 hr. in getting all the fiber ends tied and the full frame in operation. With the Lewellen transmission, the shaft is slowed down before the motor is shut down and after starting at slow speed, the shaft is gradually brought up to full operating speed.





The Oilgear variable-speed drive and its control.

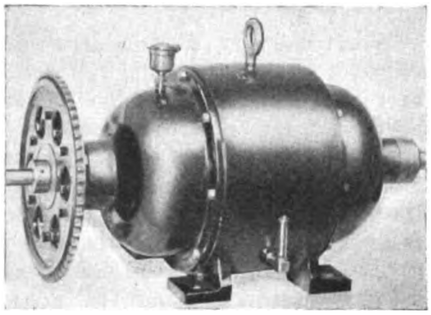
This is one of the hydraulic types of variable-speed transmission. The motor is connected to the shaft at the left which drives a variable-displacement pump that pumps oil to a constant-displacement motor in the opposite end. Any speed may be obtained from zero to the maximum input speed and in either direction of rotation.

sprockets are of semi-steel or cast iron. Chain links are heat-treated alloy steel. The pins are case-hardened nickel steel.

The various makes of silent chain differ primarily with respect to the joints; both pin-type and rocker-type joints are in wide use. The round-pin chains require oil lubrication, which is accomplished by running the chain in a bath of oil in an oil-tight case. Rocker-joint chains are lubricated with either oil or grease and should have a metal inclosure to catch the lubricant thrown from the sprockets and to exclude dirt as well as to protect the operators and the equipment.

This discussion has, up to the present, included only devices that give either no speed reduction, such as couplings, or a fixed ratio of reduction such as belts, chains, gears, and speed reducers. However, it is frequently desirable to obtain a variable or adjustable speed and at the same time use a constant-speed motor. Some of the mechanical devices that are available for doing this will be illustrated and described briefly in the following paragraphs.

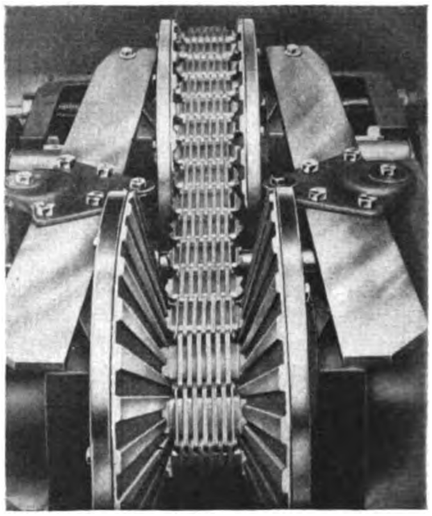
One of the more common mechanical types of adjustable-speed transmission consists essentially of two pairs of movable cone-faced disks mounted on parallel shafts and connected by a special, V-shaped belt which drives from one pair of disks to the other. Two pairs of levers, operated by right- and left-hand screws, move the disks so that as one pair separates, the other pair approaches; in this way the driving and driven diameters are changed and the speed ratio modified. The speed is regulated by a handwheel governing the above movement. Some of the accompanying illustrations show applications of this device.



One of the J. F. S. variable-speed transmission units.

The motor is connected to the high-speed shaft at the left. The slow-speed shaft at the right is provided either with an outboard bearing for pulley or gear connection, or coupling for torque load. The speed is varied by turning the wheel at the left. This is made in the form of a sprocket so that a chain may be attached for remote control. Change in speed is obtained by shifting rollers on a cone-shaped race.

This type of variable-speed transmission is available in sizes to about 150 hp. and for speed ranges from 2:1 to 16:1. Usually these units are connected to the motor by a chain that gives some reduction in speed. Often they are used with a speed reducer to obtain variations at very low speeds. Assembly conveyor drives are usually operated in this way; the speed of the conveyor is adjusted to give the desired output according to the number of men working on the assembly line.



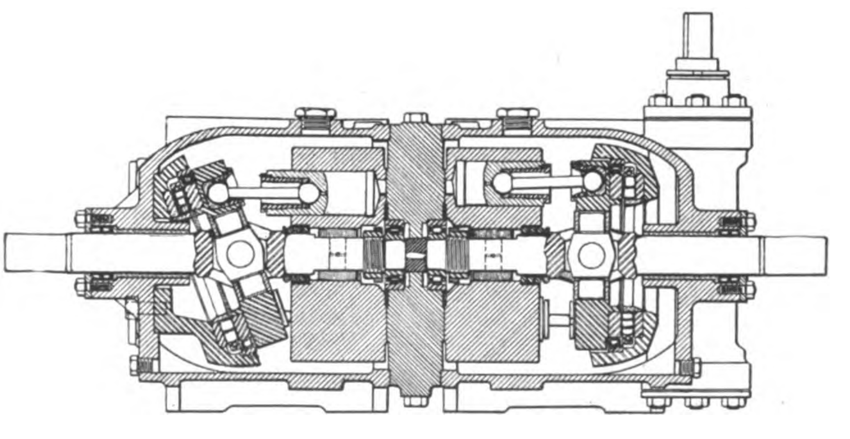
This is the P. I. V. variable-speed driving gear.

This variable-speed transmission consists of expanding pulleys of the opposed, conical-disk type which are connected by a special chain that fits into the ribbed or grooved disks. This transmission was described in more detail on page 98 of the February issue of INDUSTRIAL ENGINEER.

Slight shifting of the cones provides gradual speed adjustment in minute increments. This shifting may be controlled either automatically or manually, as desired. When equipped with ball bearings the efficiency is about 85 to 95 per cent at loads near capacity; the higher efficiency is obtained when the variable-speed shaft runs at high speed. At light loads the efficiency falls rapidly, due to fixed losses. The horsepower-transmitting capacity is greatest when the variable-speed shaft operates at maximum speed and falls off materially at lesser speeds. Hence, a knowledge of the load characteristics is important in planning an installation.

Other mechanical types of variable-speed drives are under development, and some are in operation in industrial plants on a wide variety of drives. A few of these will be illustrated and described in the accompanying photographs and captions.

Hydraulic types of variable-speed transmissions are also available. These usually consist of a motor-



Cross-section of the Universal hydraulic variable-speed gear.

These hydraulic units are made up to 200-hp. rating and will deliver any speed from zero up to input speed in either direction. The input at the left supplies varying quantities of oil to the variable-speed hydraulic motor at the right.

driven pump or turbine unit operating at motor speed that can be adjusted to circulate varying quantities of liquid, usually oil, to drive a companion unit at variable speeds, according to the quantity of liquid received. Most of these hydraulic units can be adjusted to deliver speeds varying from zero to the maximum speed of the input pump, which is usually motor speed, with an infinite number of increments in between. Also, the low-speed unit can be made to operate in either direction, although the input speed is constant and always applied in one direction.

The apparatus has a given torque capacity and will handle any torque up to rated value and at any speed. The horsepower capacity is proportional to the speed, and the efficiency is about 85 per cent at full speed and full torque. At reduced speeds and reduced torque the efficiency is lower, as the horsepower output is decreased and the losses are, therefore, of greater relative magnitude than at high speeds.

One make of hydraulic transmission, the Oilgear, has also been successfully applied as a means of translating rotary into linear motion. The pump member, driven by the motor, is connected with a cylinder the piston of which is moved at a speed corresponding to the pump displacement. This application has been made with particular success to broaching machines and hydraulic presses.

The hydraulic transmission gear has been developed in small sizes only in the United States but in England successful installations of similar character have been made on larger units. A mine hoist with a 200-hp., constant-speed induction motor drive was recently so equipped. The entire control of speed and rotation is obtained by adjusting the displacement of the pump member. One advantage of this application is the smooth acceleration obtained, with the motor running constantly at full speed and with minimum demand imposed on the power generating or distribution system.

The opportunities of using variable-speed transmission devices of both mechanical and hydraulic types have not been taken advantage of as extensively as may be possible when operating men fully understand and appreciate their uses, and the resultant advantages of obtaining and using exactly the best operating speeds.

Functions of Control

(Continued from page 208)

start has been initiated by the operator. Most controllers use this device as it is usually unsafe to have a motor start unexpectedly. A good illustration is a motor operating a machine tool or an elevator. In either case, the unexpected starting of the motor might cause serious personal injuries to someone using the machine or elevator.

Automatic contactor type control is usually arranged, so that it can be connected for either low-voltage release or low-voltage protection. Manual controllers may not provide a low-voltage device in themselves, and so may require additional control equipment to afford this kind of protection. The ordinary direct-current starting rheostat and the alternating-current auto-transformer starter have holding magnets that release the mechanism and open the circuit on failure of voltage from any cause.

Drum controllers should be provided with a protective panel for overload and low-voltage protection, as the drum controller does not usually provide such features in its own design. All safety codes dealing with this question require low-voltage protection for many applications.

Phase Failure Protection

Where the motor is connected to a polyphase source of power, an overload may be imposed upon the motor by one of the circuits being open. The most frequent cause of such failure is the opening of a fuse. If this occurs on a three-phase circuit, the motor will continue to operate at about 40 per cent overload on the single phase remaining in circuit. If the motor is fully loaded, this additional current should be sufficient to operate the overload device and disconnect the motor from the line. If the motor is operating on a light load, its windings will not be overheated and, from that standpoint, there may be no objection to its continued operation on single phase.

When one of the power wires is open, the single phase of the motor will generate a voltage between the open-circuited motor terminal and the other terminals, that will be nearly equal to the line voltage. This voltage is usually sufficient to retain any magnetic release in the closed position, so that a voltage coil usually will not afford protection against single-phase operation. A series coil can be used in each phase to protect against single-phase operation, but it is necessary to provide some special device to bridge out these relay contacts when starting, which adds complications to the controller.

The usual method of protecting against phase failure when the motor is running is to provide a torque device that operates like a small motor. Such a device can be wound and connected so that its torque will be decreased if one phase is open circuited, and it will thus afford protection against single-phase operation.

If the motor is at rest it will not start on single phase. It is easy to protect against this condition by ordinary low-voltage coils, as there is no voltage generated in the open circuit of the motor. Applications such as elevators, hoists, and the like, can have phase-failure protection in the off position that will prevent them from being burned out, due to this cause. Motor-driven pumps, fans, and so on, should either be protected by a suitable overload device or provided with a phase-failure relay.

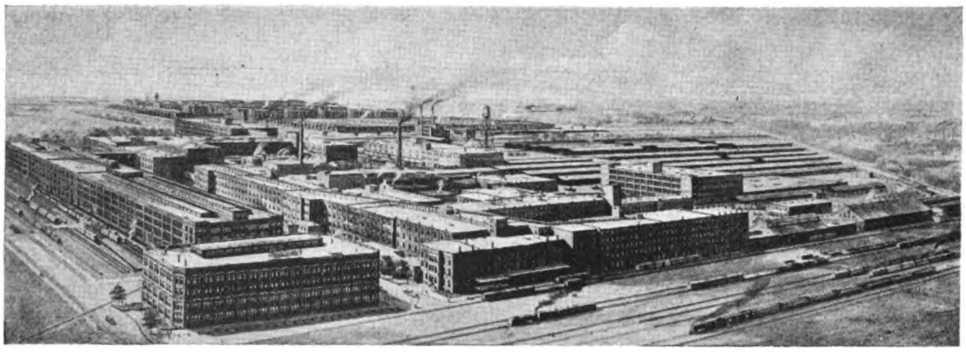
Sometimes the phase rotation in a polyphase power circuit may be reversed, by interchanging two leads at the transformer or somewhere else in the circuit. This reversal of phase may cause an accident to an elevator if its automatic stop device is so connected that it opens the wrong set of contacts. Such installations should be protected by a suitable relay. Thes relays are usually small torque devices that reverse their torque when the phase rotation is reversed. Relays of this kind are usually not necessary on other applications, as no dangerous condition is caused by phase reversal. They are, however, commonly used on certain types of elevator control.

In the above discussion a number of the more common functions of a controller have been pointed out. Other special functions may be performed when the application requires them. Each application should be analyzed and only the necessary functions specified for the controller. The simpler and less elaborate the control, the easier it will be to maintain and the less the initial cost of installation.

ORGANIZED PROCEDURE *in the South Bend Plants of the Studebaker Corporation for the*

Maintenance of Mechanical Equipment and Buildings

SECOND ARTICLE



By JOHN R. SULLIVAN

Supervisor of Transportation, the Studebaker Corporation, South Bend, Ind.

AT THE South Bend plants the Transportation Department controls and carries out the following activities: the interdepartment and interplant transportation of materials, products, and waste material; salvage work, which is largely transportation of scrap from the several buildings to a central point, from which it is handled by the By-products Division; general plant maintenance and upkeep; and plant railroad, including the repair and upkeep of track and yards, but not of locomotives. This article will cover only the work carried on by the maintenance division of this department.

Our maintenance work includes the following under the supervision of the foreman of maintenance: building painting, roofing repairs and renewals, floor repair, sewer cleaning, cleaning and repairing yards and roadways, concrete work, window washing, glazing, brick masonry, some janitor work, carpenters and handy men, labor gang, gardening and landscaping, railroad track maintenance. Approximately 60 men are employed regularly in this department. Frequently additional men, particularly laborers, are required on some of the larger jobs.

Roof Maintenance.—One of our most important jobs is in connection with the maintenance, repair, and renewal of the plant roofs. It is not the policy of the company to engage in extensive construction work. However, comparatively small jobs without unusual complications are usually performed by the company, much of it by our department, under the direction of the Construction Engineering Department. Two of the inspection engineers from the Construction Department also inspect all roofs and the whole of the foundry annually as a check-up on all building maintenance.

These inspections also back up recommendations where a department has not approved our report on the condition of the roof and need of repair. We make our own inspections and recommendations, which go with the estimated cost to the production manager and must receive his approval before the work is started. All work is done on instructions given on a regular repairs and renewals work order form and all labor and material charged against the division issuing the requisition.

The roofing gang consists of one first-class roofer, who serves as gang boss; three experienced roofers, and the necessary laborers. We have some slate and some gypsum tile roofing, although the larger proportion is tarred-felt paper, coated with asphaltum and gravel. The roofing men repair leaks and resurface or relay gravel roofs and replace broken slate or tile.

Another important part of the work is to keep the roof clean, as this not only gives the men a good opportunity to watch its condition and find small breaks, but also removes the dirt before it has washed down into the catchbasins. Approximately three gondola carloads, each holding about 40 cu.yd., are removed from the roofs monthly. The foundry roof has the largest amount of debris; a carload of material is removed from this roof every three or four weeks.

The roof on the Body Division, which has several dust and chip collectors for wood shavings, has the next largest amount of debris. This debris, which is largely sawdust, is transmitted pneumatically to the boilers along with all shavings and hogged woodwastes. Other buildings are cleaned regularly.

An important labor-saving device for removing the debris from the roofs is the use of galvanized-iron pipes or chutes extending from the roof down alongside the building. A 5-cu.yd. trailer is placed for the chute to discharge into. These trailers have metal coverings to prevent the debris from blowing about, as shown in accompanying illustration, and when filled are hauled away by tractors.

Window Washing.—All windows are washed at least four times on the inside and three times on the outside every year; no outside washing is done during December, January, and February. Windows in the

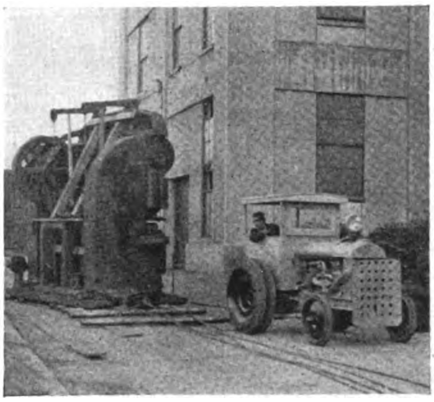
machine shop are washed every other month, however. No attempt is made to wash the windows in the forge shop, because of the heavy smoke and oil that settle on them. Window washing is a continuous operation and the men are on piecework.

A variety of cleaning agents are used in the different locations, depending upon the conditions. For example, the foundry windows are the most difficult to clean; hydrofluoric acid solution is used on them. Windows in the other divisions require the use of solutions that will remove lacquer, grease, and other deposits, each requiring some special cleansing agent.

The gang boss in charge of the window washers is also a glazier. At different times he has a gang varying from five to ten men help him. The entire plant has about 400,000 panes of glass and as many as 10,000 panes have had to be replaced during one year.

Building Painting.—The painting gang consists of about five men and a gang boss employed throughout the year. During part of the season about nine men are employed. Early in the spring the maintenance foreman and the inspection engineer from the Construction Department make an inspection of all outside work to see what will need repainting. The outside painting consists largely of upkeep on steel sash and frames. Most of the buildings are of concrete or brick with large steel sash windows. After the inspection and recommendations are made, the cost is estimated for each building, an appropriation is requested, and, with the approval of the production manager, the painting is done. Outside work is done in the summer and the gang works inside during the winter.

All inside painting, also, is done only upon the approval of the production manager. Wherever possible, the paint spray gun is used for



One of the miscellaneous big jobs handled.

This press weighs approximately 40 tons and was moved about ½ mile. Part of the haul was made by putting the press on rollers on the railroad track and it was then pulled along by the switch engine. The remainder of the move was made by tractor as illustrated. The press was placed on skids and pulled along by a block and tackle.

inside painting. New construction is painted by this gang, and when a department is moved, we always try to get in and do the painting after all the old equipment is moved out and before the new equipment is moved in. In this way we overcome one of the most difficult problems in connection with spray painting—the necessity of covering up all machines and equipment. Ordinarily, where equipment is installed, it is necessary either to do brush painting, because of the difficulty of covering up all the machines, or to do the work at night.

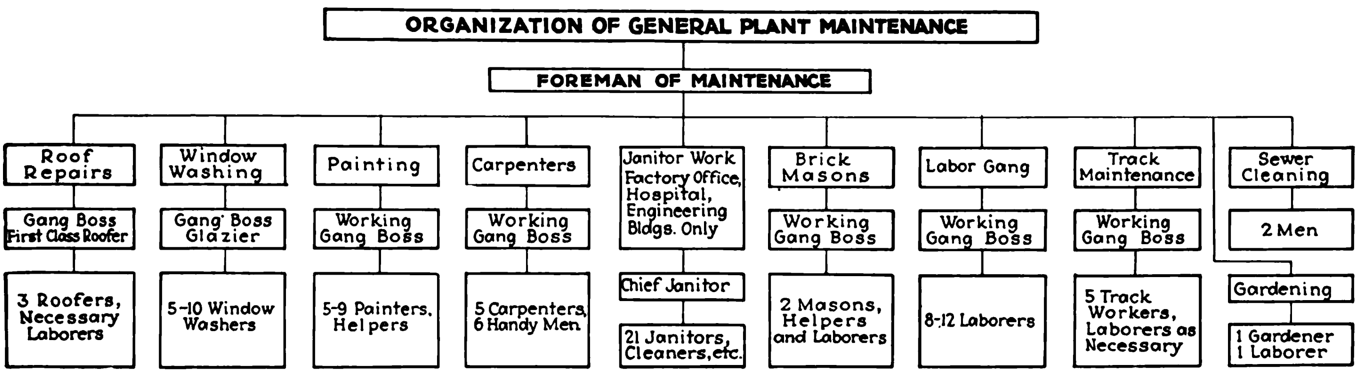
Spraying, we find, can be done, where conditions are suitable, for about one-half the cost of brushing. Instead of erecting scaffolding, we have the painter, with his spray gun, stand on a platform built on a truck and be pulled along by a helper as he needs to advance. Wherever possible, we put both brush and spray painting on a piecework basis; at present about half of it is done that way. We have found that where the wall spaces are broken up too much or where too large an amount of wall or floor space must be protected, it does not pay to use the spray.

Our practice is to put three coats of paint on new work and two coats on old. We have standard outside and inside green paint for the sash and use a standard mill white for the ceilings and walls down to within 6 ft. of the floor. A battleship gray extends from there down to the 6-in. brown baseboard. Approximately 75 bbl. of paint are used a year for painting the buildings. Each job is planned two or three weeks or longer ahead, and so the paint is ordered as needed; thus we seldom have more than 2 or 3 bbl. of paint on hand at a time. This is in line with our company policy of keeping the stock inventory down to a minimum.

Steel sash is painted approximately every 4 yr. The length of time between paintings, however, depends on the conditions surrounding the windows. For example, windows exposed to condensate or to acid fumes require painting much more frequently.

Whenever possible, we try to clean walls instead of repainting. In many cases the walls will be fairly clean with the exception of a few dirty spots around some special machines mounted near the wall. In such cases we try to clean these spots frequently. In practically all cases these spots, particularly if they are grease or oil spots, must be cleaned before they are painted over. Where a large surface is to be cleaned, the work is done on a piecework basis.

One of the painters is a sign painter and letterer. An industrial plant, such as this, has many signs, notices, identification marks and numbers for machines, bays, and so on, around the plant. A large amount of this work was necessary in con-



Organization chart covering the general plant maintenance work.

This organization is a subdivision of the transportation department and on requisition does the necessary work within its line for both Body and Chassis Divisions.

Refuse from upper floors and roofs of the buildings is dumped down the chutes into the wagon.

The same method is used for disposing of scrap and metal turnings from the various floors, except that separate chutes are used for each material. The hood prevents the debris blowing about and is raised and lowered by means of a telescopic section on the end of the chute and counterweight. When filled, the wagon is removed by a tractor.

nection with a new storage building that was recently erected. When the man is not busy at this, he works with the other painters.

Carpenter Work.—Two divisions of carpenter and woodworking activities are carried on in our plant. One division, which includes the woodworking and cabinet shop, does all work that requires the use of machines. Much of this is new work, although part of it is for repair or maintenance of buildings and plants. The new carpenter work for the whole plant is described in an accompanying article.

Our carpenter work is almost entirely for maintenance or repair, although it does some new work, such as forms for machine foundations and for other concrete work. When we occasionally have jobs that require machine work, we have it done by this other department.

Ordinarily, our carpenter gang consists of six carpenters, six handy men, and a gang boss. The carpenters make all hardwood and creosote block floor repairs which may be due either to wear or changes in plant. The carpenters also build forms for new concrete construction and for the foundations for machinery. They erect and move partitions, wooden stockracks and bins, and take care of the multitude of miscellaneous carpenter jobs that are necessary in a large industrial plant. The handy men install, adjust, or change door or window hardware, adjust elevator gates, see that firedoors and other doors close easily, and do many other "handy" jobs about the plant.

All of the carpenter and "handy" work is performed only upon requisition on a repairs and renewals work order form with proper indorsement. Some of the work, however, is prompted as a result of the inspections made under the direction of the Power Department. During the winter doors that do not close easily or entirely increase the difficulty of heating the plant. If the foreman of a department is slow in reporting this, the inspector for the Power Department, whose task it is to keep heating costs down, finds the opening and reports it. The same is true of broken windows and other heat leaks. The repairs are made by some one of our gangs.

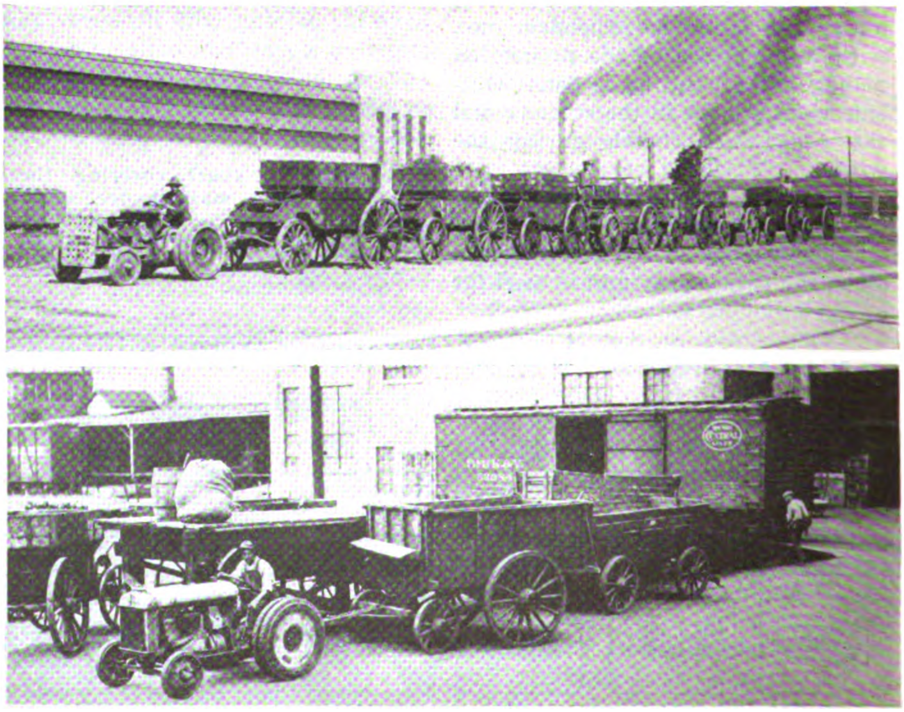
Brick Masons.—We have practically continuous work for three brick masons and three helpers under the maintenance foreman. These men reline heat-treating furnaces, the foundry cupolas, core ovens and other similar equipment using firebrick lining. They also cut holes in partitions or walls or erect new partitions. These men are all-around men and take care of the concrete work, cement finishing and plastering, with the aid of the necessary laborers.

Sewer Cleaning.—This is a very important task. The amount of work required, however, is materially reduced by the frequent cleanings given to the roofs. Sewer work is done by two men working together without any gang boss or direct supervision. These men have been at this work for a long time and are held strictly responsible for conditions. They clean all inside and outside catchbasins, and follow a regular routine and repeat. They have to keep at it continuously and know that the results are strictly up to them.

Labor Gang.—The large amount of yard cleaning and the many miscellaneous tasks are taken care of by a labor gang. The number in the gang fluctuates according to the amount of work to be done. One of the regular activities of this department consists of cleaning the yards and roadways. This gang also removes the debris taken from the roofs and handles the salvage materials. Refuse from upper floors is dumped through chutes, which also handle debris from the roofs, into the trucks, as explained. However, sweepings and other material from the first floor and yard are wheeled up a yard ramp on wheelbarrows and dumped into a wagon alongside. One of these ramps is shown in an accompanying illustration. The wagons are hauled away by gasoline tractors.

Steps in the disposal of refuse and debris.

A gasoline tractor (upper view) with a train of trailers on the way to the dump with yard and roof refuse. Refuse from the first floor and from the yard is wheeled up this yard ramp and dumped into wagons alongside, as shown in the lower illustration. This takes care of material and wastes that cannot be sent down the chute.



One of the jobs of the labor gang.

This gang furnishes the labor supply for the miscellaneous odd jobs around the plant requiring a large number of unskilled men, but not in any way connected with production. In this case they are cleaning the mud from the spray cooling pond.

Approximately 50 to 80 cu.yd. of refuse are removed daily from the ramps. In addition to this about 100 cu.yd. of cinders are removed daily during the winter from the power house and 200 cu.yd. of refuse from the foundry departments. This latter consists largely of scrap core and molding sand. All roadways are swept by a mechanical sweeper attached to a gasoline tractor, as shown in one of the illustrations.

The labor gang also takes care of the removal of snow. Also, when we have a large concrete roof, or cleaning job, or any other labor job, these laborers are called on to assist in the work under the supervision of the roofers, masons, or other gangs. They are used on practically any type of work requiring a number of unskilled laborers.

Janitor Work.—The janitor work for each production department is taken care of under the supervision of the particular department. This gives the close supervision that is necessary. The refuse, floor sweepings, and metal turnings or borings from the different floors are dumped down chutes that have openings from the various floors to a wagon at the ground level, as explained. Separate chutes and trucks are used for refuse and for each of the various types of metal wastes, so that aluminum, steel, cast-iron, and brass turnings or borings are not mixed and so lose or decrease the scrap value. These metal wastes are all hauled over to the Salvage Department for disposal by the Byproducts Division.

We do, however, have a gang of about 21 day and night janitors to take care of the Factory Office, Hospital and Engineering Department buildings. This force takes care of about 175,000 sq.ft. of floor space. Each janitor has a definite routine to follow with certain fixed work to do, and the work is on an hourly basis.

Track Maintenance.—We have our own railroad and switching facilities and have about nine miles of track. Crossings, frogs, ties, and loose spikes and bolts are looked after by a gang of five track workers. This, of course, is increased if any extensive changes are to be made.

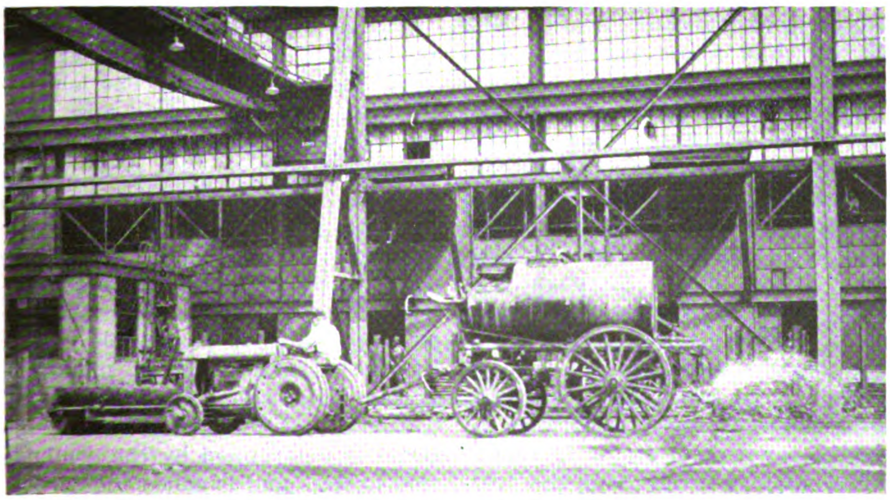
Gardening and Landscaping.—During the summer one man devotes practically all of his time to taking care of the lawn and other green spots about the plant. Part of the time this gardener is supplied with a laborer to help him. During the winter he is put in one of the gangs as a helper.

Cost Keeping.—Work is not done unless on the requisition of a department approved by the division superintendent, and after this requisition has also been approved by the production manager. An exception is made for requisitions that would involve a very small amount, such as fixing doors or windows and other items not exceeding $25 in cost for both material and labor. All items costing over that must have the approval of the production manager. Each order for work done is issued on a repairs and renewals work order form and given a job number. The men working on each job indicate the job number on their time cards. The labor cost is apportioned to the various departments after the cards go through the Timekeeping Department. The necessary materials are supplied on a stock requisition issued against this same order number. This also is charged by the Cost Department against the particular job number.

Maintenance of the plant's railroad track keeps a foreman and four men busy.

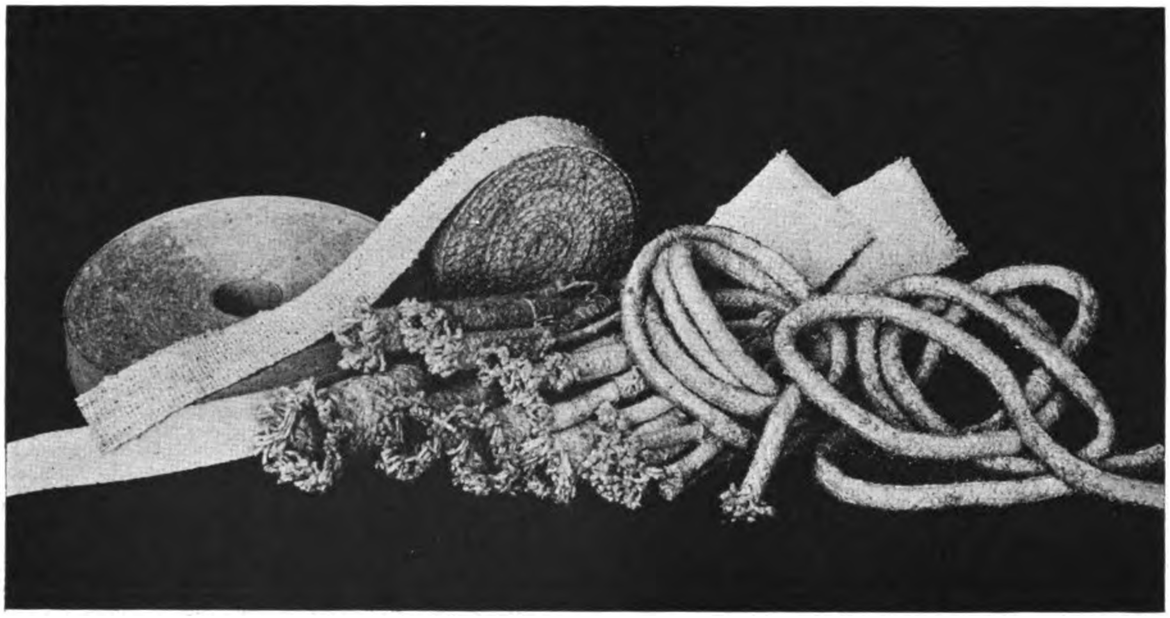
Yard and street cleaning is still another duty.

This mechanical brush, pushed by a tractor, does the work of a large gang of laborers. The sprinkling cart settles any dust that is not swept up. The dust is also removed regularly from the roofs.



Work involving a considerable expenditure is always estimated ahead of time, and the estimate is approved by the department head. It is our problem then to keep within the estimate. These orders are handled through the Estimating, Routing and Inspection Department, which issues the necessary purchasing requisition where new supplies must be purchased. However, an attempt is made in all cases to use materials that are purchased for the Production Departments and are kept in our regular stock. Although the maintenance division of our department has its own storeroom, the supplies in this are kept at a minimum and in many cases, as in painting jobs, only the amount of supplies required and issued for a particular job are kept on hand.

As the work done is always charged back to the department for which it is performed, we are watched very carefully to see that the cost of any work is not what that department considers too high.



This shows some of the forms in which asbestos insulation can be obtained. Courtesy the Mitchell-Rand Manufacturing Co., New York, N. Y.

Heat-Resisting Insulation

For Protecting Windings Against High Temperatures

By A. C. ROE
and
D. H. BRAYMER
Consulting Editor, Industrial Engineer

WHEN motors must operate near objects that radiate heat, such as hot rolls in steel mills, hot kettles, ovens, boilers and the like, and when they are called upon to carry overloads continuously during certain periods, the insulation to be used in a rewinding job requires careful consideration in its selection and application. This is particularly true in instances where the load on a motor has been changed from intermittent to continuous, such as increasing the number of lifts per hour on a crane motor, or when a motor designed for open duty is totally inclosed for operation in dusty surroundings.

In some cases the use of more copper in the coils will help to reduce the operating temperature, but in nine jobs out of ten, the use of high-heat-resisting insulation is required to prolong the life of the motor after rewinding. For full protection against high temperatures the insulation should be of inorganic composition, such as mica, asbestos, Bakelite, and so on or a combination suited to the operating conditions.

In the November issue of INDUSTRIAL ENGINEER the use of asbestos-covered wire was discussed. In this article the practical application of asbestos in other forms as an insulating material for windings will be taken up from the standpoint of high-temperature protection.

Asbestos is found in the fissures of certain serpentine rocks and cleaves in great quantities of small fibers. The characteristics of the fiber depend upon its source, some varieties being long, delicate, flexible and elastic, while others are short, stiff, and brittle.

There are two kinds of white asbestos used as motor insulation. One is lower in silica, lime and iron content than the other, but higher in magnesia and water. This is the kind most commonly used for electrical insulation. Although the other grade is slightly more heat- and acid-resisting it is rather brittle and for this reason is not used so much. White asbestos furnished for electrical work contains between 13 and 14 per cent of water in chemically combined form. It is the presence of this water that prevents asbestos from being fully fireproof. In case asbestos is subjected to a red heat the water is driven off, inducing brittleness and flaking which, if carried far enough, injures the asbestos to such an extent that its value as an insulation is impaired and it must be renewed. Asbestos may, therefore, be injured by a red hot fire, but it prevents the spreading of fire. That is, it will not carbonize and burn as would organic material, and it will not be affected by heat alone.

The color of asbestos ranges from pure white to green, blue, yellow, pink, and light brown. The long fibers are carded and spun into yarn by a process similar to that employed in the manufacture of cotton or wool. This yarn is then used in weaving asbestos cloth or tape, or braided into sleeving. Cotton is added to provide strength to the asbestos threads while spinning and weaving so that reasonable speed may be maintained in the manufacturing processes. The amount of cotton in any piece of asbestos material is determined by the combustion process and is called the carbon

content, 2.2 per cent of cotton being equal to 1 per cent of carbon, approximately.

From the above it is obvious that the quality of asbestos products can vary. For instance, in asbestos sheeting or paper there may be present some iron compounds that would greatly reduce its dielectric strength, and in some cases make the material unfit for use as insulation. In tape or sleeving if the carbon content runs high and a piece of electrical apparatus is subjected to high temperature a failure is likely to happen at a critical time.

Many manufacturing companies make tests to determine the grades of material they require and then write up purchasing specifications which indicate the kind and quality of asbestos required. These specifications give values for yards per pound, threads per inch, carbon content, tensile strength, and other requirements.

The inspection departments use the specifications to pass or reject incoming asbestos materials. Since asbestos products are expensive, and any piece of apparatus insulated with them represents a considerable cost, it follows that only the best grades of materials should be purchased, and only from a reliable source.

Asbestos Tape Insulation—Asbestos as applied to stator, rotor and field coils is used in the form of tape, sleeving and sheeting, or as asbestos paper. The tapes can be obtained in thicknesses of 0.015, 0.020, 0.025, 0.035, and 0.063 in. and in widths of 0.5, 0.75, 1.0, 1.25, and 1.5 in. for the 0.015-, 0.020-, and 0.025-in. thicknesses; 0.75, 1.0, and 1.25 in. for the 0.035-in. thick, and 0.5, 0.75, 1.0, 1.5, 2.0, and 3 in. for the 0.063-in. thick. The best sizes to stock for general repair use are 0.75 and 1.25 in. in the 0.015-in. thickness.

The 0.75-in. width, 0.015 in. thick, is used for armature coils, while the 1.25 in. is more suitable for field coils. Where the application is mostly for armature or stator coils a stock of 0.015 in. thick and 0.75 in. wide can be carried and used on field coils. In fact the 0.75-in. width will give a tighter lap, but will require a little more time to apply. However, the reduction of inactive stock will more than offset the small extra labor item.

The use of 1.25-in. tape is preferred to the 1.5-in. for field coils, since the 1.25-in. provides a tighter lap, which means that the finished coils will have a better seal. This can be proved by taping a straight bar with 1.25-in. and 1.5-in. tape half overlapped, both tapes being applied with the same degree of tension. Then pick up the edge of the lap with the finger nail, which will show that the 1.25-in. tape is tighter than the 1.5-in.

Another reason for specifying 0.015-in. thick asbestos tape for armature and stator coils is that in the majority of cases the finished tape originally used on the coils that are being redesigned with higher temperature-resisting insulation is 0.007-in. thick cotton tape, and since this tape is usually half overlapped on the ends, there would be a total of four thicknesses or 0.028 in. of cotton on each coil end. With the thinnest asbestos tape half overlapped we would have four thicknesses or a total of 0.060 in. which would tighten up the end windings, and if end space is limited it may be necessary to just barely butt the asbestos tape. That is, leave a small space 1/64 in. between each turn of tape, which would reduce the total thickness to 0.030 in. of asbestos tape.

Three Ways to Make Coils for High Temperatures

[1] Increase the copper area and use asbestos-insulated wire.

[2] Use asbestos-covered round, square or ribbon wire with mica wrapper and asbestos tape.

[3] Use bare copper strap coils, mica-taped with mica wrapper and asbestos tape.

The method to use will depend on the operating conditions. Study each case and apply the heat-resisting materials best suited to these conditions, as explained in this article.

Asbestos tape when applied to coils as a finishing tape has a ragged appearance with small particles or ravelings sticking up somewhat like lint on cotton goods. If the coils are dipped in this condition the finished coils will have a ragged look and the projecting pieces will be hard from soaking up the varnish. There are two ways to overcome this. One is to hot-press the coils in the slot sections and rub the hand over the ends, which will knock off most of the loose projections. The other is to rub and trim off all loose projections or ends by hand. This is another item to watch in buying asbestos tape, as some grades may have more loose ends or ravelings than others, particularly at the edges of the rolls. In some cases these ends do not show up until the tape is being unrolled. Anyone who has unrolled straight-cut friction tape and had it ravel will understand what takes place.

The number of threads per inch and the weave have considerable effect on the strength and ease of application of asbestos tape.

Asbestos Sleeving—This form of asbestos is used as lead coverings. The wall thickness and inside diameter of this sleeving vary with the different manufacturers. Some grades are coarse and have as high as 1/16-in. wall thickness, whereas other grades can be obtained with a wall thickness as low as 1/32 in. Two sizes, 1/8-in. inside by 3/16-in. outside diameter, and 1/4-in. inside by 5/16-in. outside diameter, are the best sizes to stock, as these will cover the majority of wire sizes.

When using asbestos sleeving it should be cut into the shortest lengths possible. After putting it over the wire, pull it out and fasten both ends with glue. There are two reasons for this. The first is that asbestos is expensive and stretching the sleeving means economizing in material. The second reason is that in pulling the sleeving up tight the bulk is reduced, thus allowing the leads to be put down without crowding.

Asbestos sleeving can be checked by the number of yards per pound and the number of threads. The yards per pound is important, inasmuch as sleeving is purchased by the pound, but used by the yard. If the wall thickness is excessive there will be less yardage, and a bulky job will result.

To check the number of threads, cut off about 1 in. of the sleeving and stretch or work it until the threads separate; then pick the piece of sleeving apart, one thread at a time, and count off the threads. Next, cut off 1 lb. and check the number of yards in a pound. Put these figures on record for future checking.

Asbestos Paper—Asbestos paper is a combination of asbestos fiber and paper, compressed but not sized. Asbestos paper should be carefully selected to avoid the presence of

small particles of iron oxide or magnetite like scale or grit in the fibers. Although these are very small particles, a microscopic inspection of the paper will in some cases reveal several such particles per square inch.

This paper can be obtained in various grades, according to the carbon content. In this class we have asbestos paper tape. This material is better than the sheet material since its carbon content is lower and it will stand higher temperatures without carbonizing.

In most cases the tensile strength of asbestos paper in sheet or tape form is very low and it should not be used as a binder for the outside finish of stator or armature coils. It can, however, be used for the outside finish on small magnet coils and the like.

The major use of asbestos paper or paper tape is between turns of strap-wound field coils. For this purpose the material should not be less than 1/16 in. wider than the copper strap, nor thinner than 0.007-0.010 in. or 0.015-0.020 in. These are the sizes that are most frequently used.

The following simple precautions should be taken when using asbestos paper or tape between turns of strap copper coils: First, keep the paper dry. Asbestos is hygroscopic and will absorb considerable moisture in the ordinary storeroom; therefore, any coil wound with asbestos paper between turns should be thoroughly dried before being dipped in varnish or impregnated. If the coil cannot be dipped and baked, the material should be placed in an oven and dried and used as needed.

This applies to such types of apparatus as the revolving fields of two-pole turbo-generators—those having horizontal slots in which the copper strap is wound directly with asbestos between turns. It is obvious that these slots are deep and if any moisture is present in the paper, it would be an extremely hard matter to drive it out; if it is not driven out it will be the cause of serious trouble. In cases of this nature put the asbestos paper in an oven and bake it dry. Keep it under heat during the day so that each roll of material used will be bone-dry.

Asbestos string or cord can be used for bands, tying coils and filling the back of commutator necks.

When rewinding electrical apparatus for operation at higher temperatures, we have the following conditions: (1) Cases where an increase in copper area and the use of asbestos-insulated wire will reduce the full-load or operating temperature to a degree that will permit the use of cotton finishing tape with a mica wrapper. (2) Cases that will require asbestos-covered round, square or ribbon wire with mica wrapper and asbestos tape. (3) Bare copper strap coils, mica-taped with mica wrapper and asbestos tape.

On direct-current armatures, or wound rotors for alternating-current motors, inorganic material should be used under bands, core insulation, and so on. Also, pure tin solder should be used to fasten the bands and leads in the commutator necks.

When armatures or rotors have fiber retaining wedges, these should be left out and band grooves cut in the core to provide for core bands. Stator wedges can be made from slate, ebony, asbestos, transite and the like. The lead jumpers, star connections, and so on on stators should also be covered with asbestos insulation.

As already mentioned, asbestos is expensive both as a material and to apply; so each job should be studied and the material used in a manner that will do the most good. For instance, do not half-lap the tape if slightly spacing it, say 1/32-in., will do. Do not use round wire and asbestos tape if the use of square wire will reduce the temperature.

Combination Mica and Asbestos Paper—Another asbestos material is a combination of mica and asbestos paper. This has a layer of mica between two layers of asbestos paper and is used between the sections of strap-wound field coils. It has high dielectric strength as well as high-temperature-resisting qualities. When these materials are used the finished coil should be treated with a baking varnish that will not run under high temperatures and that has a heavy body.

Asbestos fibers are combined with synthetic resins to make molding mixtures that set on the application of heat and in their final state are resistant to high temperatures, oil, and acids, and in addition are waterproof.

Liquid Bakelite, which is a synthetic product, is a varnish-like liquid that hardens under the application of heat. After it sets heat will not soften it even though it be heated to a carbonizing temperature. This material has high mechanical strength and heat-resisting qualities and can be used to impregnate asbestos wire coils. When hot-pressed it will hold the wires together, or the finished armature can be dipped in liquid Bakelite.

Do not dip and bake finished coils, as this will cause them to become too hard to handle. If apparatus is too large to dip, the coils can be dipped in Bakelite and allowed to air dry for a few hours; then put them in the machine in the green state and bake the complete apparatus. Asbestos paper when impregnated with Bakelite becomes brittle and unless the paper is well supported, Bakelite should not be used with it.

Some Don'ts When Using Asbestos

[1] Do not allow asbestos insulation to absorb moisture. When using it be sure that it is bone-dry.

[2] Do not half-lap asbestos tape when a spacing of 1/32 in. will be satisfactory.

[3] Do not use round wire and asbestos tape when square wire will reduce the operating temperature sufficiently.

[4] Do not dip or impregnate coils insulated with asbestos until they have been thoroughly baked.

[5] Do not use a cheap grade of asbestos; the best grade economically used and properly applied is the cheapest in the end.

Legibility of Color Combinations Used on Danger Signs

TO THOSE interested in the legibility of "danger" signs, here is the net result of an investigation conducted to determine the relative values of colors in order of legibility, as given in *Town Topics* (Thomas Insulator Co.): (1) Black letters on yellow background. (2) Green letters on white background. (3) Blue letters on white background. (4) White letters on blue background. (5) Black letters on white background. (6) Yellow letters on black background. (7) White letters on red background. (8) White letters on green background. (9) White letters on black background. (10) Red letters on black background.

Operation and Care of Storage Batteries

IN ORDER to deliver the service that it is capable of rendering, a storage battery must be given a certain amount of careful attention. The consequences of neglect may, for a time, be slow in appearing, but eventually the battery will be ruined or get into such bad condition that costly repairs will be required. On the other hand, attention to a few simple details will not only prevent trouble but very materially lengthen the life of a battery. The instructions given in this article are from the Manual of Storage Battery Practice of the Association of Edison Illuminating Companies, presented at their forty-second annual meeting.

THE most common causes of plate trouble in storage batteries are short-circuits, abnormal sulphation and impurities in the electrolyte. Short-circuits may result from the positive and negative plates coming in contact by buckling; by the displacement of the small hanging lugs, or from particles of lead or other metals lodging between them from spongy growths or from scale on top of the plates bridging over between them; and from sediment in the bottom of the tanks accumulating sufficiently to touch both positive and negative plates.

If a short-circuit is caused by buckling or breakage of plates, the trouble should be remedied by replacing the separator, or possibly by inserting a strip of thin wood, in addition to the old separator, at the location of short-circuit. When the plates are in such condition that the trouble cannot be permanently overcome, it will be necessary to replace them. Straightening of plates has been tried at various times, but the operation has been found to be rather unsatisfactory.

Small pieces of metal may occasionally fall into a cell and by lodging between the plates cause a short-circuit; this is particularly likely to happen at the time when the plates are burned in, either during installation or when subsequent repairs are made. For this reason careful inspection should follow the work.

After a battery has been in service for some time, there may appear a deposit of spongy lead on the top of the negative plates, due to excessive charging or a deposit of scale on the positive plates. This deposit should be removed before a sufficient quantity accumulates to bridge across the plates.

Loss of Active Material from Plates

In proportion to the amount of work done by the battery, the positive plates lose their active material, which falls to the bottom of the tank as sediment. Tanks are built with a space under the plates sufficiently deep to receive all the sediment that will be deposited during the entire life of one set of positive plates. In stand-by batteries a 6-in. sediment space is considered sufficient. In batteries that are in active service, with old style tanks that have shallow sediment space, it is necessary to keep a check on the depth of the sediment that accumulates. and remove it before it touches the bottom of the plates and short-circuits them.

The presence of a short-circuit in a cell is indicated by its behavior as compared with other cells. Its specific gravity will fall off, its voltage will drop below normal, there will be some rise in temperature, and the cell will be slow in gassing or will not gas at all on charge.

A simple method used for detecting short-circuits in a cell is to measure the voltage drop across the connecting lug of the negative plates with a millivoltmeter. A cell having an internal short-circuit will give a slight indication across the lugs of the plates which are not in trouble and a very much greater indication across the lug of the plate in trouble. When the negative plate that is short-circuited is determined, the two positive plates adjacent to it are tested for the exact location of the short-circuit. The separator is then pulled out, the short-circuit cleared and the old separator, or a new one if necessary, installed.

This reduces the amount of labor in the clearing of short-circuits. With close checking of the specific gravity, individual cell voltage and temperature, and the use of the above method of clearing trouble it is possible to maintain the cells without a large loss in capacity, oftentimes eliminating a separate cell charge. A millivoltmeter with a low scale is satisfactory for this purpose. When measuring the lug drop, the first contact must be made at a point somewhat above the electrolyte level and the other contact then made at the top of the lug. If the reverse order of making contacts is followed there is danger of damaging the meter, from the lower prod touching the electrolyte.

Cells that have been short-circuited should receive a separate charge sufficient to restore them to normal condition, after the cause of the trouble has been removed. The active material is partly sulphated, which is a normal condition, but when a cell does not receive sufficient charge to reduce all the sulphate formed during the discharge or by local action, there is a gradual increase in the amount of sulphate until it assumes a hard, crystalline form unmixed with active material. This condition is termed abnormal sulphate. Hard sulphate is a poor conductor of current, and when abnormal sulphating has occurred, a charge extending over a long period at a low rate is required to reduce the sulphated material to normal condition. Conditions of operation that produce abnormal sulphate are: Standing discharged for a long period, habitual undercharging, the unnecessary addition of electrolyte instead of water to replace evaporation, and neglect of short-circuited cells.

Effect of Foreign Substances in Electrolyte

Certain foreign materials that may enter the electrolyte increase the action upon the plates considerably beyond normal, reducing both the capacity and the life of the plates.

Iron in a cell discharges both the positive and negative plates, by being deposited on them and creating local action. If it is present in sufficient quantity, it seriously attacks the positive plates and materially shortens their life. The presence of

iron may be detected by a light yellow coloring of the positive plates and a strong odor.

When copper is present in the electrolyte it is deposited upon the negative plates and forms local elements which discharge the plates. The presence of copper is indicated by liberation of gas at the negative plates when the cell is not charging, and by a copper coating on the lugs.

The effect produced by chlorides or nitrates is an increased formation of material on the positive plates, shortening their life and in some cases resulting in their buckling.

It is detrimental to the plates if the fumes of muriatic acid or ammonia are allowed to enter the battery room and remain there any length of time. Batteries located near chemical works are especially exposed to this danger.

Cause of Failure to Deliver Rated Capacity

The failure of a cell to deliver its rated capacity may be due to the natural wearing out of either the positive or the negative plates, or to any of the causes mentioned in the preceding paragraphs.

The plates will give rated capacity as long as they have sufficient active material in good condition, and in the proper state of porosity and contact. The natural wear of positive plates consists in the gradual loss of active material; that of the negative plates, in the loss of contact and porosity by reason of shrinkage of the active material.

Under some conditions it may be expedient to make partial plate renewals. Plates of like polarity of different age or design should not be installed in the same cell. The positive and negative plates, however, may be of different ages.

There is a gradual lowering of the specific gravity of the electrolyte due to minute quantities of acid being carried off with the gassing spray on each charge, and to the sediment that accumulates in the bottom of the tanks absorbing some of the acid. These losses must be made up, but only at long intervals or when the gravity, with the battery fully charged, has fallen 30 points (0.030 sp.gr.) below normal. To raise the gravity, add new electrolyte of normal strength when replacing evaporation, repeating until the gravity of the cells is restored to normal, after which water should again be used for replacing evaporation. Acid of a density higher than 1.300 specific gravity should never be added to the cells, as electrolyte or higher densities has been found to be detrimental to the plates. In purchasing acid, however, a saving can be effected by procuring acid up to 1.600 specific gravity, which may be reduced by mixing with water and which is safe to handle in the mixing process.

Inasmuch as certain impurities in the electrolyte are detrimental to the plates, special care must always be taken to insure that both the acid and the water used in the battery are suitably pure. Local water may or may not meet the requirements. The suitability of either acid or water always should be passed upon by the battery manufacturers, who will analyze samples free of charge. This applies also to electrolyte in cells in which impurities are suspected. Not less than eight ounces of electrolyte or one quart of water are required for analysis.

If harmful impurities are present in a cell, the safest procedure is to remove the electrolyte immediately, flush the cell thoroughly with water and refill with fresh electrolyte. This new electrolyte should be of the same specific gravity as that drawn from the cell and adjusted if necessary to normal gravity after the cell has been given the proper charge.

Maintenance and Repair of Battery Tanks

The subject of battery maintenance concerns the life of the tanks as well as that of the plates. This is especially true of batteries in stand-by operation where long life of plates may be expected. Plates that are considerably aged may not bear handling, although if not disturbed they would last for a much longer time. Therefore, if for no other reason, tank renewals and repairs should be kept down to a minimum.

To obtain the greatest life from wood tanks, it is important that the battery room be kept as dry as possible by proper ventilation and care, and that the battery be equipped with cell covers. Overflowing cells when adding water should be avoided.

The tanks should be painted with a good grade of asphaltum paint at the time of installation, and should be repainted whenever the coating shows signs of deterioration. Raw linseed oil acts as a preservative and a light coating should be occasionally applied to the tanks. If the wood checks from shrinkage, the openings should be filled with thick paint or with compound. In old tanks the woodwork is likely to open up at the dove-tailing and, if taken in time, may be repaired by bracing with insulators or by banding.

Leaks in tanks are caused by punctured linings, seam holes and electrolysis. Punctures arise from accidents or carelessness in handling. Electrolysis is caused by electric leakage from the cell to ground, as a result of the insulators becoming coated with a film of acid or dirt, or being broken. Electrolysis is more likely to occur on the positive side of a three-wire system battery with a grounded neutral, as the lead linings of these cells are positive to ground. These troubles are not common in present-day practice where oil insulation is used. Seam holes are due to improper lead burning.

Minor leaks can usually be repaired by a lead patch, but frequently electrolysis may have advanced so far before being discovered that it may be necessary to put in a whole new bottom lining, extending several inches up the sides of the tank. The wood of the tanks becomes more or less soaked with the acid that has leaked through the lining, and before relining the acid should be neutralized with air-slaked lime and the wood dried and painted. The insulators should be kept free from dirt and acid film. Cracked or broken insulators should be replaced.

It is recommended that air-slaked lime be used on the floors to offset any acid spray or drip from the cells. Air-slaked lime absorbs the moisture and neutralizes the acid. A thin layer spread on the floor under the tanks and about 2 in. into the aisle from the tank will be found to be satisfactory. This keeps the floor dry.

Protection of Copper Work Against Corrosion

The care of the copper work in battery rooms is mainly a matter of cleaning and preventing any products of corrosion from falling into the cells. Copper parts should be painted with white lead or coated with heavy oil or grease as a protection against the acid spray. The use of heavy oil or grease, while satisfactory as a protection against corrosion, has the disadvantage of being unsightly and of collecting dirt and dust. The copper-supporting structure should be protected against acid fumes by the application of acid-resisting paint. The practice of applying acid-proof compounds on horizontal metal parts of the battery has been found to be satisfactory.

An operator's viewpoint on

Industrial Equipment Advertising

used by manufacturers, with some comments on its value as pre-purchase information

DURING the time I have been writing this page for INDUSTRIAL ENGINEER, many mighty fine letters have been received telling about interesting experiences, the problems confronted, and the features that are right and wrong about machines, men, and all other things that enter into the life of the operating man. These letters have reflected experience, lots of it, and a careful digesting of the material appearing in this publication, from cover to cover. That is to say, the advertising pages get a thorough going over: so thorough, in fact, that errors in statements or impressions are frequently mentioned.

In this connection you will be interested in the following comments on advertising by E. J. Morrissey of Aurora, Ill., who is one of our readers and an old-time operator:

LET me say at the beginning of this letter that the first knowledge that I had of Practical Pete's existence was when the mailman laid INDUSTRIAL ENGINEER on my desk. Therefore, neither Practical Pete nor I can be accused of a conspiracy or collusion in the writing of what is to follow.

As I glance through the pages of trade and technical magazines, I am very much impressed by the quantity of advertising used by manufacturers of industrial and power plant equipment and supplies—somehow or other it not only furnishes an idea of their size but of their growth as well. As the months pass by, I also note that a growing number of bulletins of individual firms make their way to my desk, not to speak of the great influx of calendars and the like that appear at certain times of the year.

I believe that we have one of the most modern and up-to-date plants in the country, with efficiencies and economies that our load and conditions warrant, and it is not a peculiar fact that practically all, if not all, of our equipment was purchased from manufacturers whose advertising can be found in the most conspicuous places of nearly every publication I receive.

Very often the manufacturer also uses a useful item to keep his product before us. There is the diary of one company, the notebook of another, a handbook from the third: letter openers, ash trays, blotters, bulletins, line books and a variety of miscellaneous articles that perform a useful function in ordinary life and serve as a real advertising medium that means money well spent. And yet we find a few who confine their efforts to sending calendars only, with the perfectly natural result that if all the calendars received in many offices similar to ours were used for their intended purpose there would be enough to paper the wall three deep. This does not mean that we do not appreciate the efforts of these manufacturers. I can assure you that every legitimate piece of advertising is appreciated and very often is a real source of information.

With reference to advertising pages, it is a disappointment to a reader of a magazine to pick up a late issue and feel so sure he knows what advertisement the X & Y firm are running that he is willing to bet with his friends on it. Advertisements go stale with the operator, if they are not changed and made informative.

There was a time when "the best mouse trap" could be manufactured in the woods, but nowadays it is necessary to beat the track to the buyer's door. This can be accomplished through live advertising in the magazines, or by helpful aids, and through personal solicitation.

I believe the greatest disappointment I ever noted in advertising was the short-sightedness of a large firm that manufactures a good product. I had occasion to use quite a number of their units and wrote for a catalog and parts list. Nothing was forthcoming until a second letter elicited the statement that they had forwarded these items to our purchasing agent. Now, we have a very estimable purchasing agent, but how in the world could they expect purchases of their equipment to originate if I, as the user, could expect no more attention. On a purchase order I would surely be out of luck—and so would that firm.

Advertising can be a decided waste, regardless of cost, or it can be one of the few items that will serve to bring about a better understanding between the manufacturer and purchaser, through its pre-purchase educational value. For this reason every operator should read the advertising of the firms mak- the equipment he uses, or contemplates purchasing.

WE WELCOME letters from our readers, giving the operator's viewpoint on every phase of plant work. We want to help you with your operating troubles, buying problems and requirements, and all questions relating to plant operation and maintenance. If you have any ideas, experiences, or questions, that you want to pass along, write to me and I'll put them up to other operators for their comments and suggestions.

Practical Pete

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Editor*

Paint Is an Important Factor in Industrial Lighting

THE dingy factory with bare lamps or poorly designed shades hanging close to the operators is still far too common. Comfortable lighting is impossible in such interiors because the lamps or lighting units are glaring against dark backgrounds. It is becoming realized that paint is a valuable ally in making the lighting comfortable. If painted white the walls, and particularly the ceiling, need receive only a small quantity of light to aid materially in reducing glare.

Some modern industrial lighting units have been designed to permit a small percentage of the light to escape upward. Where such units are not used, the small amount of light reflected upward from the floor and other objects illuminates the white-painted ceiling sufficiently to reduce the glare of the lighting units. This is the chief function of white ceilings from the viewpoint of lighting when the level of illumination at the work is only a few foot-candles.

As higher levels of illumination are desired the ceiling must play a greater part. At the present time a factory with 10-foot-candles at the work-plane is out of the ordinary, but the student of lighting knows that levels as high as 20 to 40 foot-candles are economically desirable. Some are already looking toward levels as high as 50 and even 100 foot-candles.

To obtain such levels without utilizing the ceiling as a secondary light source will likely be unsatisfactory from the viewpoint of eye comfort. The day has arrived for seriously considering the importance of well-maintained white ceilings which may provide an appreciable indirect component in industrial lighting. This is thoroughly practicable in many industries.

Separate Maintenance From Production

IN SOME plants it is still the practice to have maintenance taken care of by production men. This is wrong from several viewpoints, as a recent instance shows.

Operation of several unloaders used for removing coal from boats at a large coke plant was at first attempted on the hit-and-miss system of having on each unloader an operator who was supposedly responsible for getting his share of the boat unloaded. This arrangement soon resulted in the boats being unloaded so slowly that in several cases demurrage charges were incurred. It did not take the management long to find out that a good dock superintendent was required to oversee the operation of the unloaders and other equipment on the dock.

The production man placed in charge of this work was so successful in getting the boats unloaded that complete supervision of the dock equipment, including electrical and mechanical maintenance, was given to him. Soon, however, the management began to complain about heavy repair costs on the unloaders. There were innumerable armature changes, many rewind jobs, gears broke, and so on.

What was the trouble? Simply that maintenance was being sacrificed for production. As the dock superintendent was primarily responsible for production, he sacrificed the equipment in order to get production.

This usually happens when the production superintendent also discharges the functions of a maintenance superintendent. Maintenance should be in charge of a man who will stand up and fight for the proper operation and care of equipment. It may be possible to kill two birds with one stone, but in this instance the chances of doing it are very slight.

There Are Definite Reasons for Chronic Motor Troubles

THE squirrel-cage induction motor is about as simple in construction as anything that has yet been devised for a power drive and when properly applied gives less trouble than almost any other piece of electrical machinery. When misapplied and abused, however, it may show such a variety of distress indications as to puzzle experienced motor men and cause no end of worry and repair expense.

Motor trouble often occurs on installations in which the manufacturer furnishes a direct-connected motor with the machine he makes and this complete machine is sold by a representative who knows more about his machine than he knows about electrical equipment and the varying conditions under which the motor must operate. When motors are used with a rating close to the brake horsepower demanded by the machine, or under rated voltage, crowding a machine only slightly beyond its rating through the working of different materials may result in motor heating that cannot be blamed on the motor. Such conditions may at times be severe enough to trip overload control devices and tempt the operator to set them beyond the safe limit for the motor. A breakdown in the coils or a burnout is the natural result.

When troubles are experienced with induction motors, the safest way to proceed is to get a

graphic meter reading of the ampere or kilowatt demand of the motor over a period long enough to include all conditions under which it is operated. If the trouble is in the motor this record will show it in such form that it will be easy to convince anyone of the reliability of your test. If the graphic record does not show that the trouble is in the motor, then look for it in the driven machine and the conditions under which it is operated. In nine cases out of ten when the size of the motor is adequate, the source of the trouble can be located in the carelessness of someone who installed the machine or is operating it, or else the machine is doing work for which it was not designed.

Under such conditions the electric motor is simply the safety valve or distress signal and does something for the machine that the latter cannot do for itself. Oftentimes it requires more commonsense than technical knowledge to discover this fact and apply the remedy.

Standardization of Machine Speeds Will Simplify Operation

A STEP that is now being taken toward the standardization of machinery speeds will be watched with interest by all industrial operating men. This move has recently come in the form of a request made by the National Electrical Manufacturers' Association to the American Engineering Standards Committee to take up the matter.

Under present conditions there is an endless variety of sizes of pulleys, gears, sprockets and other auxiliary transmission units which the manufacturer, jobber and dealer must keep in stock in sufficient quantity to supply any probable demand. The user must also keep a variety of such parts on hand, many of which are not interchangeable or usable anywhere except on the original installation.

As matters now stand, the curve of the speeds of driven machinery is practically a random distribution without any logical order. Although the need for simplification of the speeds of driving and driven units has been apparent for years, without co-ordination and national standardization no satisfactory solution could be reached.

It is to be hoped that standardization will result in a comparatively small number of co-ordinated speeds for the almost innumerable kinds of machinery. This would help to solve the problem of simplification and standardization of pulleys, gears, and so on, would permit greater flexibility in the selection and use of power units and driven machinery, and promote interchangeability of units. At the same time, many industries that are dependent on the manufacture and use of such equipment would be able to effect worth-while manufacturing economies.

Operating men in many plants have already standardized on motor and lineshaft speeds, and frequently have changed pulleys on purchased machines to make them conform to these speeds. Oftentimes special equipment has been required, but where a sufficient amount of equipment can be standardized it has always paid because of the convenience in making changes.

Relief from the nightmare of odd and special sizes of power drive equipment will be welcomed by every plant operator.

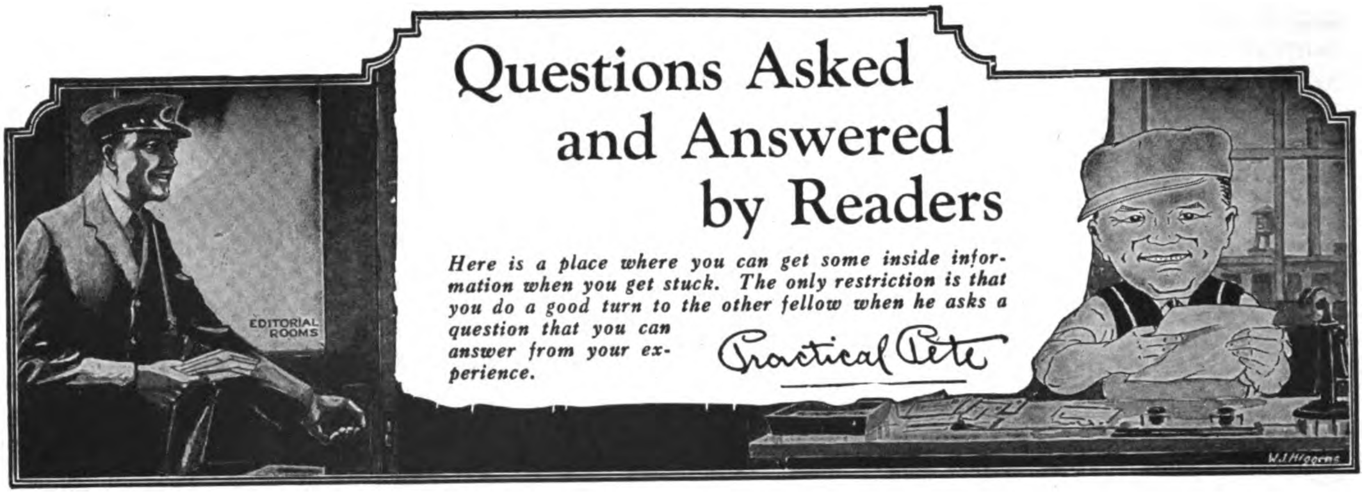
Show Your Men How to Lubricate New Equipment

PERHAPS no other single factor in industrial operating conditions is so important as lubrication. Manufacturers of practically all types of equipment are today redesigning their products to improve the bearings and at the same time provide for more reliable lubrication. The application of ball or roller bearings and improved splash and circulating systems for speed reducers and enclosed gear drives, are examples of what is being done along this line. The desire to reduce friction is only one of the reasons for these changes. Simplification of the lubrication problem is practically as important as the saving of power; this is the condition in at least a large percentage of instances.

Some industrial operating men, however, apparently still believe that if a small amount of lubricant is good a large amount is better. With the old type of loose-fitting bearing the important factor was to have a supply of lubricant always feeding down into the bearing. The exhaustion of this supply was generally fatal to the bearing.

In the lubrication of many types of modern equipment the lubricant is used over and over because the dust-tight inclosures keep the lubricant and bearing surfaces free from contamination. In a number of instances, however, users have complained of serious heating. Investigation has shown the cause to be too much lubricant in practically every case. Thus, in one plant a number of worm-reducer drives were heating because the gear cases had been filled to the top with oil. Ball or roller bearings with the grease chambers packed full under pressure will also heat, without apparent cause.

Such troubles are obviously due to the fear of the old-time employee that the small amount of lubricant recommended will not be enough. Operating executives in charge of power transmission equipment can well afford to take a few minutes to explain the changes in lubrication methods and requirements that have been brought about by the development of new types of bearings and improvements in old designs. It is no longer necessary to "oil every day to keep trouble away." It is essential, however, that the oiler understand what too much lubricant, as well as too little, will do, and why.



QUESTIONS

Who Can Answer These?

Calculation of Multiplier for Portable Graphic Wattmeter

I want to use a 5-amp., 110-volt, 2,400-kw. scale graphic wattmeter in connection with 100 : 1 ratio current transformers. What meter constant will result when using 3,200-kw. paper? What formula may be used to determine constants on meters having other than 5-amp. coils, when using different combinations of current transformer ratios, scales, and paper? B. U. D.
York, Pa.

Eliminating Dead Spots in Squirrel-Cage Motor

We converted a General Electric, form L, internal-resistance type induction motor to the squirrel-cage type by cutting out the resistance and short-circuiting the two-circuit star rotor connections. When starting with the compensator dead spots are encountered. I wish some one would please tell me how to overcome this trouble. L. J. L.
New York, N. Y.

Relation Between Power Factor and the Coal Pile

In trying to improve the operating efficiency of our plant a question has come up regarding the effect of power factor. We generate our own power and use about 600,000 kw.-hr. annually. Our generating and distribution equipment is of ample capacity, although we are operating at a power factor of only 65 per cent. I understand the effects of low power factor on the distribution system, but should like to know just how it affects the coal pile. I wish some reader would explain this, as I want to determine whether it will pay us, from the standpoint of fuel economy, to raise our power factor to 90 per cent, or thereabouts. E. A. W.
Toronto, Can.

Repulsion-Induction Motors Fail to Start

Several new $\frac{1}{4}$- and $\frac{1}{2}$-hp., 110/220-volt, single-phase, repulsion-induction motors operated satisfactorily for a few months, but now they either fail to attain full speed or refuse to start even under no load. Sometimes when the armature is turned over so that the brushes touch a different bar, the motor will start. The commutators are not rough or badly blackened, and tests indicate that the motors are in good condition. A receiver test, made when the short-circuiting device is removed, indicates that there are no open circuits in the armatures. Dead spots on the commutator do show up, but when it is turned over a few bars, these dead spots give a good test and the parts which previously indicated a good test give a poor one. Operating these motors under ideal voltage conditions does not help to cure the trouble. Will readers please suggest the cause and remedy for the trouble with these motors? W. S. B.
Quebec, Can.

What Causes Blowing of Fuses on Transformer Bank?

We have two 50-kw. transformer banks serving separate heating loads and when they are connected in parallel on the secondary side the fuses blow on one bank. Everything on the nameplates of both banks corresponds except the polarity. One bank is marked Subtractive, while the other is marked Additive. Will readers explain the meaning of these markings, and tell me if this difference in polarity has anything to do with the blowing of the fuses? H. B. D.
Lynn, Mass.

Installing Anti-Friction Bearings in Sleeve-Bearing Motors

We have a large number of induction motors of modern design, ranging from 10 to 75 hp. in size, that are fitted with ordinary sleeve bearings. Many of these motors operate in a very dusty place and considerable trouble has been experienced from rapid bearing wear. On all of our motors we have had trouble with oil slinging, which has caused a number of failures. For these reasons we are considering installing ball or roller bearings. Accordingly, I shall appreciate it if readers will tell me (1) their experience with these bearings and (2) give me some information on how to install them in place of the present babbitted sleeve bearings. (3) Can you give me any data on the cost of making such a change? L. M.
Joplin, Mo.

Cutting Out Damaged Coil in Winding

Will some reader please give me a diagram of a chorded split loop winding showing the method of cutting out a damaged coil? I should also like to know if this type of winding does not have a much longer lead throw than the straight loop winding. Can it be wound with two wires in hand and connected to a commutator with twice as many bars as coils? Would the method of cutting out a coil be the same as when wound with one wire in hand? J. B.
Los Angeles, Calif.

ANSWERS

Received to Questions Asked

Effect of Doubling Speed of Lineshaft

We have a lineshaft operating at 250 r.p.m., driving a number of woodworking machines. I am considering doubling the speed of this lineshaft: that is, increasing it to 500 r.p.m. This will give a better belt drive from the motor to the lineshaft, as then I will not need to use so small a motor pulley. Also, a number of the pulley ratios from the lineshaft to the jackshaft will be changed, as I am going to increase the speed of most of the machines only about 30 to 50 per cent instead of doubling them. There is no noticeable vibration in the lineshaft at present. As nearly as I can determine from computations, however, the shaft is well loaded at the present time and I should like to know what the effect will be when I increase the speed, and whether I might have to put in a new shaft, assuming that the present shaft is carrying full normal load for its size and speed. I shall greatly appreciate any information that readers may give me on this problem. G. G. K.
Milwaukee, Wis.

INASMUCH as G. G. K. has not given the size of his lineshaft, number or kind of machines being driven, or the horsepower of the motor, it is quite difficult to advise him intelligently, although a few points that should be of some value to him are as follows:

(1) To increase the speed of the lineshaft will require more power.

(2) When the lineshaft is speeded up, it must be better balanced in order to obtain as smooth operation with no more vibration at the higher speed.

(3) For the sake of safety, discard all wood pulleys that are larger than 18 in. in diameter, and replace them with steel ones. E. L. WAY.
Ada, Ohio.

IN REPLY to the question by G. G. K., a well erected lineshaft should stand the increased speed without trouble, although if any defects are present in the shaft, a breakdown is more likely to occur than when the shaft is operating at the lower speed. Any trouble would be more likely to develop at the supporting bearings than in the shafting itself, for these

were probably designed and erected to support a shaft to be run at 250 r.p.m. They might stand the increased speed without much trouble, but if overloaded as well, serious overheating and damage at the bearings would result. All bearings should be kept under constant observation for overheating immediately after the alteration, for the risk of breakdown will naturally be increased at the higher speed and some minor alterations at the bearings may be found necessary. W. E. WARNER.
Shefford, Bedfordshire, England.

DOUBLING the speed of a lineshaft automatically doubles its capacity for power transmission, and although G.G.K.'s shaft is well loaded at present, it should carry twice as much horsepower when the speed is doubled; that is, so far as the horsepower capacity of the shafting itself is concerned.

The general formula used for the horsepower capacity of shafting is $D^3R \div 75$, and when the bearings are 8 ft. apart, the horsepower may be determined by the formula $D^3R \div 50$, when D equals diameter of shaft and R equals r.p.m.

Safe Capacity of Shafting

Diam. in. Inches	Hp. at 250 r.p.m.	Hp. at 500 r.p.m.
1 3/16	5.58	11.16
1 7/16	9.90	19.80
1 11/16	16.02	32.04
1 15/16	24.24	48.49
2 3/16	34.89	69.78
2 7/16	48.28	96.55
2 11/16	64.70	129.4
2 15/16	84.49	169.0
3 3/16	108.0	215.9
3 7/16	135.4	270.8
3 11/16	167.1	334.3
3 15/16	203.5	407.0
4 7/16	291.3	......
4 15/16	401.2	......
5 1/2	554.6	......
6	720.0	......
6 1/2	915.4	......
7	1143.0	......

The data in the accompanying table were taken from the mechanical section of the Standard Handbook for Electrical Engineers, but similar results may be obtained by using the general formula mentioned in the above paragraph. It is evident from this table that doubling the speed of a lineshaft also doubles its horsepower capacity. E. J. MORRISSEY.
Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Operating Generators in Parallel

I have a 400-kw., three-wire, 110/220-volt, compound-wound, General Electric generator which I wish to operate in parallel with a 100-kw., two-wire, 220-volt, Crocker-Wheeler generator. Can these two machines be satisfactorily operated in parallel while the 400-kw., three-wire machine is supplying a three-wire, 110/220-volt load? If not, why not? If so, what scheme of connections must be used and what precautions observed in paralleling them? Can the three-wire machine be operated as a two-wire machine and paralleled with the other two-wire machine? How should I go about paralleling them in this case? Any information that readers may give will be greatly appreciated. J. F.
Dansville, N. Y.

IN ANSWER to J. F.'s question, the machines mentioned can be operated in parallel. When it is desired to operate a three-wire generator in parallel with a two-wire generator, it is necessary to re-connect the series, the commutating, and the compensating fields of the two-wire generator.

These fields of the two-wire generator should be split into two parts. When splitting up the series, the compound and the compensating fields into two sections, one section should be connected to the positive side of the circuit and one section to the negative side. For instance, all the south poles of the series field should be connected in series on one side of the armature and all the north poles in series on the other side. With this arrangement, neglecting the leakage flux, all the poles will be magnetized alike, for if we assume that all load is between the neutral and the line connected to the south series field, then the flux produced by the current flowing in these field coils must flow through the north poles of the generator in completing the circuit.

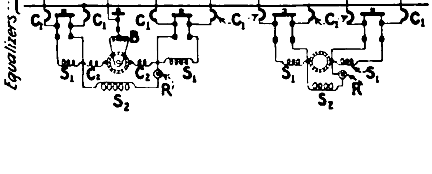
Now, as each of the generators is arranged for two series fields, the machines must be connected to each other, as shown in the accompanying illustration, by two equalizers, although any unbalanced load must be carried by the three-wire machine alone. With the exception of the connections of the three-wire generator, the method of connecting both generators should be the same. It will be noticed, however, that when a three-wire generator is operated in parallel with another generator, two equalizers are needed, whereas only one is needed between two-wire generators.

To provide adequate protection, the circuit breakers must be connected between the machine brushes and the equalizers in order that the tripping elements may be actuated by the full armature current. The two single-pole breakers on the positive and negative leads must be interlocked. Otherwise, should only one breaker open, the compensator or balance coil maintaining the neutral would have to carry the full armature current and would probably be damaged. If placed between the series field and the busbars, the device would be actuated by a current sometimes greater and at other times less than the armature current, depending on the direction in which the equalizer current is being exchanged between the machines. The equalizers are at terminal potential, and unless the voltage is fully built up on the incoming machine before it is paralleled with the running machine, the current in-rush is likely to damage the armature of the incoming machine. For this reason, switching equipments should be such that the series field will be connected in the circuit before the generator is paralleled.

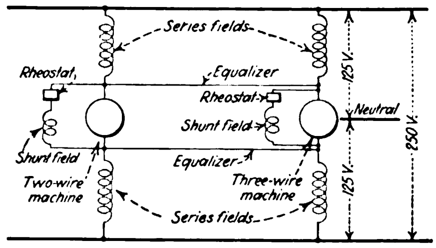
Owing to the fact that unusual care must be exercised when paralleling three-wire, d.c. generators it is advisable that a voltmeter be employed to reduce the likelihood of an accident. When paralleling, as already mentioned, the series field of the incoming machine is connected first; then the two single-pole breakers are closed, one at a time. By connecting a double-reading voltmeter across the last circuit breaker, an indication would be obtained of any unbalanced condition between the two machines; which would make paralleling impossible. H. J. ACHEE.
District Line Superintendent,
Southwest Light & Power Co.
Elk City, Okla.

This shows how a three-wire and a two-wire generator may be connected in parallel.

In this diagram C_1 represents the circuit breaker; C_2, commutating field; B, balance coil; R, rheostat; S_1, series field; and S_2, shunt field.



ANSWERING J. F.'s question, I would suggest that he refer to a book written by Gandy and Schacht entitled "Direct Current Motor and Generator Troubles," published by the McGraw-Hill Book Co. It is possible to parallel the generators he mentions, providing the series field of the two-wire generator is divided into two parts. One half of this series field should be connected to the positive side and the other half to the negative side of the armature. Two equalizers, however, will be required.



This shows how a two-wire and a three-wire compound-wound generator can be connected in parallel.

The accompanying illustration shows how these connections should be made. For best results the series field circuits of the generators should be closed at one time, by means of a four-pole switch or circuit breaker on the two-wire machine and a five-pole switch or circuit breaker on the three-wire machine. HORACE TURVILLE.
Lansdale, Pa.

THERE is no reason why J. F. should not be able to parallel his three-wire, 110/220-volt, compound generator with a two-wire, 220-volt generator, provided that the latter is also compound wound. It is advisable, however, to employ two equalizers, connected at a point between the series field and the armature of each unit. The series field of

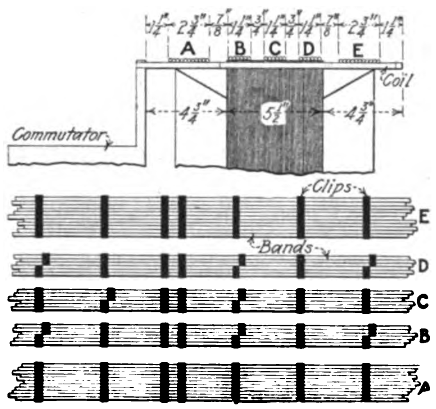
the two-wire machine should in this case be split into two sections, one half or all north poles being connected on one side and the other half or all south poles on the other side of the armature. The generators can in this way be operated in parallel as though the third wire on the 400-kw. machine did not exist.

FREDERICK KRUG.

Assistant to President,
Porto Rico Railway, Light & Power Co.,
San Juan, Porto Rico.

What Causes Armature to Throw Core Bands?

We are having trouble with the bands on an armature of a 75-kw., 2,400-r.p.m., 230-volt, 200-amp., four-pole, compound-wound turbo-generator. On account of a breakdown the coils were removed from the core, reinsulated, replaced, and connected as before. The winding was then tested with a growler and also a millivolt drop test was made. Next the five steel bands were installed as shown in the diagram. Each band is separate from the others and is thoroughly soldered, with sheet copper reinforcing clips placed at six equi-distant points around the core, except at the start and finish of the band, at which point two copper clips were placed close together. After fitting the bands and again testing the winding,



the armature was replaced and brought up to speed with the field circuit open. The field circuit was then closed and when the generator voltage rose to approximately 100 volts (less than half rated voltage), the bands became so hot that the solder loosened and the bands were thrown off. The air gap was ample, so that the bands were not striking the pole pieces. Furthermore, there was absolutely no indication of heating or other trouble in the winding itself. Will some reader please tell me what causes this armature to throw its bands? Is the trouble caused by having more than four equally spaced sets of copper clips around the periphery or by having two clips together, or both? Any information that readers can given me as to what is causing my trouble will be greatly appreciated. W. H. E.
Richmond, Va.

REFERRING to W.H.E.'s trouble with the heating of band wires, the kind of banding wire used is very probably the cause of the heating. Band wires are subject to two causes of heating, hysteresis and eddy currents, both of which are due to magnetic effects and not to mechanical friction.

Assume a small length of band wire is located directly beneath a North pole of the magnetic field. While it is in this position the magnetic lines of force pass from the pole face of the field coil across the air gap and into the armature, traversing a path perpendicular to the wire's axis. Now, assume this same portion of band wire moved to a point midway between a North and a South pole face. The magnetic lines in this case become parallel to the band wire. Again move the wire so that it is under a South magnetic pole. The magnetic lines are again vertical to the axis of the wire but they move in the opposite direction to those under the North pole, and in the last part of the cycle the lines are again parallel to the wire. Thus, as each small portion of the band wire is a conductor cutting through a magnetic field, current will be generated in the wire.

The effect on the wire is the same as though it were placed in a field produced by an alternating current. The relative movement of wire and magnetic lines is such as to generate an electromotive force which will cause alternating currents to flow in concentric circles about the axis of the wire. These currents are known as eddy currents and are dissipated as heat. These losses which they cause are proportional to the conductivity of the wire, the square of the frequency, and the square of the flux density of the magnetic field. As the latter two factors have been previously determined for a given machine, the band wire should have a high resistance in order to keep the losses from eddy currents at a minimum.

Referring again to the movement of a small length of the wire through the magnetic field, the flux reverses its direction through the length of wire as the wire passes through the cycle previously described. If the wire contains any magnetic material, this reversal of magnetism causes heating due to hysteresis losses. Hysteresis losses are proportional to the frequency, to the flux density with an exponent of 1.6, and to a coefficient of hysteresis which depends upon the material. This latter factor is the only one affected by the material used for banding wire and should be as low in value as possible. This factor varies considerably for different materials and may be 80 or more times as high for tungsten or manganese steels as for transformer stampings or ordinary iron.

By applying these facts to W.H.E.'s turbo-generator, the heating of the steel band wires is easily accounted for. The frequency of the generator is $(4 \div 2) \times (2{,}400 \div 60) = 80$ cycles, as compared with the frequencies of 10 to 40 ordinarily used in d.c. generator designs. It is also probable that the flux density is high. As the steel band wires are of magnetic material, they would have a very high hysteresis loss and a moderate eddy current loss.

It is suggested that a tinned bronze wire be used for banding W.H.E.'s case. As bronze is an alloy of nonmagnetic metals, the hysteresis loss would be negligible. In general, as the tensile strength of bronze is increased by varying its composition, the conductivity decreases at a very much higher rate. A bronze wire of high tensile strength would then have only a small loss from eddy currents and practically none whatever from hysteresis.

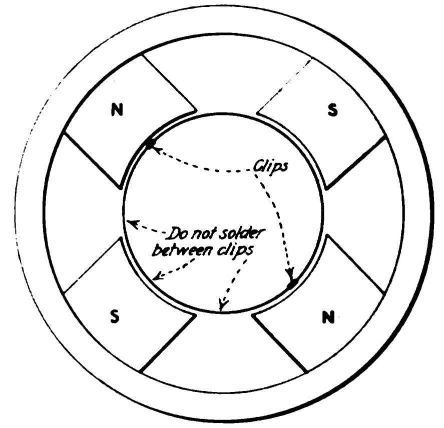
C. W. PEDEN.

Assistant Electrical Engineer,
Aluminum Company of America,
Massena, N. Y.

I WOULD suggest that W.H.E. replace his present core bands with brass ones, but make the width of the bands only one-half that of the former width. The bands should be insulated from the core with either mica or a good grade of insulation, such as horn fiber or fullerboard.

The present trouble is being caused by bands that are too wide and that act as a secondary circuit in the magnetic flux which passes through the air gap. The bands now used cover up too much of the armature core. The writer is quite certain that, if W.H.E. tries the method suggested, he will have no further trouble with the core bands coming off. AXEL T. SMITH.
Smith Electrical Works,
Sioux City, Iowa.

IN ANSWER to W.H.E., the writer would say that it is a good plan to have no more clips on the core bands than there are pairs of poles. In this case two clips only will be needed and they should be equally spaced. The core bands should be insulated from the core, and no solder



This diagram illustrates where the core bands should be soldered.

should be used on the bands between the clips, as indicated in the accompanying illustration.

Apparently, W. H. E. has by soldering the bands around the core provided a good conductor for the current which is generated in them, this current being sufficient to heat the bands and clips until they loosen.

ALBERT E. CARPENTER.
Shelburne Falls, Mass.

THE trouble experienced by W.H.E. with hot core bands on a 2,400-r.p.m., four-pole armature may be due to any one of several causes. One sure cause of heating is the all-over soldering of the bands. Solder should be applied only at the clips and kept confined to within ½ in. or so of the clips.

Another sure cause of heating results from the use of more than two clips, for two clips only should be used and spaced equally distant around the armature. Another cause of heating may result from using bands 1½ in. wide; consequently it might be well to separate each band into two bands,

each being about ⅝ in. wide and so spaced that the bands or clips will not touch each other. In regard to the kind of band wire used, I imagine that the manufacturer of W.H.E.'s armature may have originally used phosphor-bronze band wire, although it is not necessary to do so.

The rebanding of the armature may be accomplished in accordance with the following procedure:

Anchor the end of the band wire to a peg forced between the armature coils at the end of the core. Wind the wire on the core under heavy tension, using thin cut mica under the wire to insulate it from the core. Lay in two ⅝ in. wide, soft, tinned copper clips, spacing them at opposite diameters of the core. Wind the band wires close to each other for a width of ⅝ in., and then bend over the copper clips and solder them, but do not cut the wire, for it should be extended around the armature a few inches beyond the last clip before laying in a clip for the next band. Wind this band in a manner similar to the first one.

One continuous wire can be used to make up all the bands on the core, the ends of the wire terminating at the ends of the core, which are about the coolest places on the armature. The two clips of one band need not be located with reference to the clips of the other bands, the only requirement being that the two clips of one band should be located at opposite diameters of the armature. If good phosphor-bronze wire is used, it should not need tinning, as it will generally take solder readily, but in the event that a flux is needed rosin flux or rosin-core wire solder only should be used. When heavy head bands are used trouble is often experienced with them, if they are soldered all around the armature. Even on these bands two clips only should be used, soldering them at opposite sides of the armature.

Waterbury, Conn. ROBERT B. TREAT.

THE trouble that W.H.E. is having with his band wires is peculiar, in a way, but his difficulty can be easily explained and cured, if my theory is correct.

To start with, by revolving a solid iron or steel core in a magnetic field, eddy currents are set up that tend to heat the core. I have no idea how far this heating effect would go in the way of temperature, but I know that it will generate sufficient heat to destroy insulation on electrical conductors. This was proved by a case that I had, where a melted section of laminations next to a slot caused several breakdowns until the cause was found.

It is only natural to suppose that at least some of the heating in H.W.E.'s bands is caused by eddy currents. As the eddy currents flow they heat the bands until the melting point of the solder is reached, when it softens enough to cause the bands to loosen. The obvious remedy for this trouble is to use band wires made of non-magnetic metals. In this case it may not be desired to use a non-magnetic metal; so the next best remedy is to use only two clips on each band, making the bands as narrow as possible. Solder the bands only at the clips, leaving the wires parallel, but do not solder bands together around the armature between the clips.

This method of remedying W.H.E.'s difficulties offers such few opportunities for the formation of eddy currents that those which are active are practically harmless. Eddy currents are present, of course, at each clip, but the heat generated is carried away so rapidly by the unsoldered wires on each side of the clip that its temperature does not reach the danger point. If this heat were not dissipated weakening of the solder would result and loss of the band would follow. I know by experience that this method works, for after adopting this method in my shops, there have been practically no failures of bands on any armatures. I feel certain that the cause of the core band failures that we have had in the past has been found.

R. R. SCHELLENGER.
Supt. Electrical Department,
Elk Horn Coal Corp.,
Wayland, Ky.

MY SUGGESTIONS in answer to W. H. E.'s question only apply to the bands *B*, *C*, and *D*, in his illustration, and with the understanding that no current was drawn from the armature when trouble was experienced with the core bands.

The core bands were evidently loosened by their heating, which was caused by a combination of hysteresis and eddy current losses. Wide steel bands that protrude slightly above the armature teeth cause the air gap at the bands to be less than it is at the armature teeth, in which case the bands are likely to heat. Bands *B*, *C*, and *D*, are quite wide and should be split into six or seven bands and, if possible, these should be wound directly on the laminations without any insulating mat under them, in the event that it is necessary to use steel wire. The flux of the main field flows the whole distance of a pole pitch through the bands, but if they were down on the teeth of the core the air gap would be greater around the bands and consequently the hysteresis losses would be lessened. Any decrease in the hysteresis losses in the bands caused by the increased air gap, or in any manner, will improve the regulation of the machine.

In a machine of this character with comparatively few slots per pole, fairly thick steel and high densities, I would not anticipate any difficulties from winding steel bands directly on the laminations.

By using a non-magnetic material, such as bronze, for the *B*, *C*, and *D* bands, all the above-mentioned hysteresis losses will be prevented, and regulation will be improved. The area of the bronze wire, if adopted, should be about 2½ times that of the steel wire. The bronze bands will have more eddy current heating per unit width than the old bands, but this will be more than offset by the reduction in heating due to the elimination of the hysteresis losses from the bronze bands. The bronze bands seem best adapted for this machine, but the precaution must be taken to make them less than ½ in. in width. The spacing between the bands is immaterial and can be ⅛ in. or less.

On this particular job I do not believe that the number or position of the clips appreciably influences the loosening of the bands.

Baltimore, Md. GUY K. MITCHELL.

Heating of Fan Motor

I have rewound a 16-inch desk-fan motor, using a coil span of 1-and-3 instead of the former coil span of 1-and-6, and using the same number of turns, coils, and size of wire as formerly used. The motor now operates at a normal speed of 1,750 r.p.m., but becomes abnormally hot within a few minutes after starting. Most of the heat seems to come from the stator iron rather than from the coils themselves. What is the cause of this and how can it be corrected, keeping the present 1-and-3 slot winding? The motor is of the split-phase type, having four poles, 24 slots, and 24 coils with 58 turns of No. 24 single cotton-covered enameled wire per coil. It is rated at 110 volts, 60 cycles. The original winding had a coil span of 1-and-6, 83⅓ per cent pitch. I shall greatly appreciate any information that readers may give me on this problem.

St. Louis, Mo. T. A. B.

IN REPLY to T.A.B.'s question, the first important fact to notice is that reducing the coil pitch has an effect similar to reducing the number of turns per coil, in which case the self-inductance of the coil would be reduced. This effect on the number of turns is not in direct proportion to the percentage of slots dropped, but varies as the sine of one-half the angle in which the coil spans in electrical degrees. Assuming a span of 1-and-6 to be 100 per cent pitch, it follows that with a span of 1-and-3 the cord factor would be approximately 0.64 instead of 1. From this it is evident that the motor is working at about 156 per cent overvoltage.

The heating in T.A.B.'s case is caused by excessive losses, which include both I^2R and iron losses. The former is due to the increase of current used, and the latter is on account of the greater magnetic density of the iron and the increase in eddy currents. If the number of turns per coil is increased to 90 or more, the trouble will be somewhat lessened; however, if the size of wire is reduced to accomplish this, the power of the fan will have to be reduced accordingly. Otherwise, excessive I^2R losses would give trouble again.

In the case of a 16-in. fan motor, it is not feasible to change from a span of 1-and-6 to 1-and-3, if at the same time the original number of poles is to be retained. FRANK HARLE.

Rochester, N. Y.

Data for Building Auto-Transformer

I wish to build an auto-transformer for use on 110-volt, 60-cycle current. This auto-transformer should have a capacity of 15 amp. and should have taps for voltages of 10, 20, 30, 40, 50 and 80 volts. I had planned to use a core made up of iron wire. Will this work satisfactorily? Can some readers give me the correct dimensions of the core that should be used, the size of wire, and the number of turns of wire that will be required? I shall appreciate your help.

Bayonne, N. J. E. J. M.

IN REPLY to E.J.M.'s inquiry, I would strongly advise against the use of iron wire for a core. I am giving below details of a transformer which requires 14.5 lb. of iron, the laminations being about 0.014 in. thick. This iron can be bought, probably cut to size, from almost any manufacturer of transformers or motors, and perhaps from a repair shop. Starting with the core, proceed with the construction of the transformer as follows:

Cut enough laminations, 1.5 in. x 5.625 in. for two cores, allowing 4.62 lb. per core. This iron should be stacked between two templets spaced 7⅛ in. apart, butting the individual laminations alternately against the templets. When stacking is completed, the core iron should be drawn together in a C-clamp, or vise, and then wound with friction tape over the solid portion, which should measure 2.25 in. in thickness. The yoke iron (top and bottom) is cut 1.5 in. x 3.125 in., the total weight being 5.2 lb. These laminations are inserted in the spaces provided for them in the cores, after the coils have been wound on the cores. The solid portion of the cores will measure 4.125 in. in length. The insulation around the cores, and also between the layers, should be cut 4 in. wide, which leaves $\frac{1}{16}$ in. for pressboard under the top and bottom yokes. Insulation should be provided as follows: Around the core use 0.05-in. paper or fullerboard, and between the layers 0.01-in. paper or empire cloth.

Two coils are required, one for each core. Each coil is wound on an insulated core with 110 turns of No. 10 square B & S gage d.c.c. wire, as follows: The first three layers are wound with 28 turns per layer; the fourth layer contains 26 turns. The winding occupies 3.5 in. on each layer, leaving a ¼-in. space at each end. About 183 ft., or 7 lb., of wire is required. Both coils must be wound in the same direction, as shown in Fig. 1 in the accompanying illustration.

Taps are taken from the left-hand coil at the 10th and 50th turns from the start, and from the right-hand coil at the 10th and 30th turns from the start of the winding. For taps, strap copper ⅜ in. wide should be doubled around and soldered to the wire. The taps should be carefully insulated with paper or empire cloth from the rest of the layer in which they are connected. All leads and taps should be wound with cotton tape to the point of connection with the coil. The two start leads, *St.* in Fig. 1, must be permanently connected together when the transformer is completed. The last layer on each coil should be covered with cotton tape.

The two coils, or legs, are then placed side by side and the laminations for the top and bottom yokes inserted around the coil. The entire transformer may now be impregnated, if desired.

With 110 volts impressed across H_1 and H_2, the following voltages may be obtained:

Volts	Leads	Volts	Leads
10	C-D	50	A-C
20	C-E	60	A-D
30	B-D	70	A-E
40	B-E	80	B-F

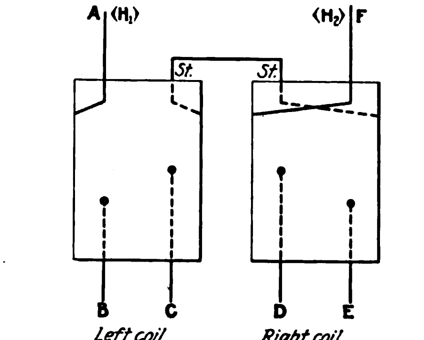


Fig.1

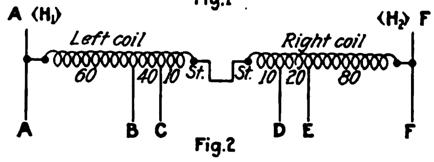


Fig.2

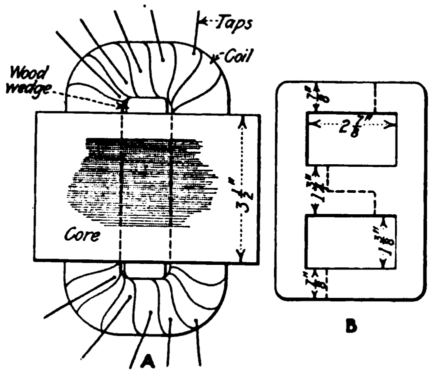
This shows the construction of a 15-amp., 110-volt auto-transformer which is tapped for 10, 20, 30, 40, 50, and 80 volts.

The iron loss will be from 10 to 20 watts, depending on the quality of the iron. The I^2R loss will be about 10 watts when the connected ratio is 110 to 50 volts, and the transformer is delivering 15 amp. This gives an efficiency of about 97 per cent, and the no-load current will be about 0.7 amp.

The No. 12 s.c.c. or d.c.c. wires in parallel, wound simultaneously side by side, may be substituted if No. 10 wire is not available. This will require an extra layer and a half, keeping the same number of turns, 110 turns per coil; so taps must be soldered to both wires in this case. Fig. 2 in the illustration shows the development of the winding, and the number of turns between the various leads and taps. Leads H_1 and H_2 should be connected to *A* and *F* respectively, when permanent connections are made to the 110-volt line.

St. Louis, Mo. T. A. BRENNER.

IN ANSWER to E.J.M., the writer has made auto-transformers similar to the one he has in mind. The coil of those I made were wound with a total of 230 turns of No. 12 wire and was designed for continuous duty at 220 volts. As each turn makes a difference of 1 volt, E.J.M. can arrange the taps on his coil to suit his requirements. It will be



This auto-transformer was designed for continuous service on 220 volts.

necessary to take the taps off the coil at the ends only, as indicated in the accompanying illustration at *A*. The core is made of 3½-in. iron shaped as shown at *B*. ALBERT E. CARPENTER.

Shelburne Falls, Mass.

Size of Alternator Required for Industrial Plant

We wish information on selecting capacity of alternators for small a.c. power plants for industrial use. (1) Recently we had to calculate the size of generator required to drive two 175-hp., 80 per cent power factor, three-phase, 60-cycle, 257-r.p.m., 440-volt, synchronous motors direct-connected to ammonia compressors, and three or four small, squirrel-cage induction motors aggregating 60 hp. The generator was required to be able to start one synchronous motor at full line voltage when the other synchronous motor was already developing full capacity. What generator capacity would be required to handle this load?

(2) Another recent case involved the electrification of a small factory. There were about ten 5-hp. motors, four 10-hp. motors and two 25-hp. motors, all squirrel-cage induction motors; the lighting load was about 5 kw. and there was one passenger elevator requiring one 7½-hp. motor. It was desired to have the three-phase, 60-cycle, 220-volt generator direct-connected to a crude oil engine. What capacity of generator would be required in this case? In arriving at the size of generator required, is it enough to add the various full-load currents of the motors and use this as the size of the generator? How do we take into consideration the power factor and the inrush current taken by the motors in starting? How can we be sure that the voltage will not drop very much so as to cause flickering in the lights when the motors are started, especially when the elevator is operating? A. B.

Lima, Peru.

REPLYING to the question by A. B., I would say that usually the problem of insuring adequate capacity in small industrial installations is not so much a question of generator size as it is of having a prime mover of the proper size for the conditions.

It is inherently difficult in small installations to eliminate voltage fluctuations and speed variations entirely when a large motor is started up, so the size of the prime mover and the generator is generally such that enough excess capacity is available to allow only a little disturbance under the worst operating conditions.

(1) Assuming that the synchronous motors could be excited for a leading power factor, it will be found that they have more than enough capacity to make up for the lagging power factor of the induction motors so that the generator could be run at unity power factor. Then, as there is a total load of (175 × 2) + 60 = 410 hp. or 306 kw., a 300-kva. alternator would be adequate for ordinary running conditions, since all motors would probably not be loaded up to capacity. The additional capacity required to provide for starting the second synchronous motor when one is in service together with the other motors can no doubt be neglected, since a synchronous motor cannot be started under heavy load, and the starting current required by this motor will not much exceed the full-load current with properly designed starting equipment. The most certain way of settling this point is to obtain the characteristic curves of the synchronous motors and the generator

from the manufacturer who is to supply them.

(2) In this case there are no synchronous motors to correct power factor and the generator must have sufficient capacity to take care of the lagging current due to the induction motors. Now, the power factor of the induction motors when operating will depend on a number of factors the principal ones being the speed and the load on the motors. Assuming that the motors have been selected with as high a speed as the drives will permit, and that their size is such that they are fully loaded, a power factor of at least 80 per cent, should be obtained. The power load should be $(5 \times 10) + (10 \times 4) + (25 \times 2) + (7.5 \times 1) = 147.5$ hp. or 110 kw.

With a power factor of 80 per cent the theoretical generator size would be $110 \div 0.8 = 137.5$ kva. After adding to this figure 5 kva., which represents the lighting load (as this load is non-inductive, kw. = kva.), there will be a total of 142.5 kva., and the nearest available commercial generator size will probably be found to be 150 kva. A generator of this size will be fully capable of handling any momentary overload incident to starting up the last motor when the others are in service.

To keep the disturbance of lighting at a minimum, the generator should be provided with a quick-acting, automatic voltage regulator, and the prime mover with a sensitive governor. Upon these two devices, more than anything else, will depend the smoothness of operation.

FREDERICK KRUG.
Superintendent of Power Production,
Porto Rico Railway, Light & Power Co.,
San Juan, Porto Rico.

Changing Speed of Induction Motor

I have a 10-hp., 1,200 r.p.m., 220-volt, three-phase, 60-cycle, Westinghouse squirrel-cage induction motor that has 54 slots and 54 coils having a span of 1-and-8. Each coil is composed of 15 turns of two No. 16 d.c.c. wires in parallel. The winding is six-pole and is connected two-circuit star. I wish to reconnect this winding so as to have the motor develop 10 hp. at 1,800 r.p.m., when used on the same supply as before. Can some of the readers tell me how to reconnect the motor to obtain this result?
Chicago, Ill. C. R.

IN REPLY to the question by C.R., I would suggest rewinding this motor as the most satisfactory means of obtaining the best results, but if C.R. does not care to spend the money for rewinding, the motor can be reconnected with the present coils.

As the span is only 1-and-8, the starting torque, when connected four-pole for 1,800 r.p.m. will be reduced considerably, and the motor may fail to start its former load; however, by killing 6 coils and 48 coils, which means 12 coils to a pole instead of the full 54 coils with 9 coils per pole for 1,200-r.p.m. operation, the motor will operate.

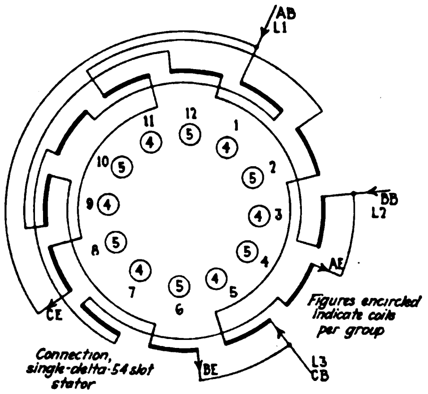
The original two-star connection should be changed to single delta to take care of the increase in the number of turns in series caused by the regrouping.

If the motor is rewound and reconnected entirely, it will develop approximately 15 hp. at 1,800 r.p.m., but if it is reconnected as I have suggested, I doubt if more than the 10 hp. will be developed.

LEE F. DANN.
Donnacona, Que., Can.

REPLYING to the question by C.R., the motor can be reconnected for 1,800 r.p.m., at the same voltage and approximately 15 hp.

A change in speed is equivalent to a change in voltage; so the windings must be changed accordingly. The two definite limits to the speed in this case are mentioned in a book entitled "Alternating Current Armature Winding,"



This diagram shows the connections of a three-phase induction motor for changing the speed from 1,200 to 1,800 r.p.m.

by Terrell Croft, in which it is stated in section 150 that, (1) the speed (peripheral speed) of the rotor, should not exceed 7,000 f.p.m. (2) The pitch factor should not be greater than 1.5 or smaller than 0.5.

When the motor coils are not divisible by the number of poles or groups, usually an unequal grouping can be arranged, and in this case that would be necessary. For example, $54 \div 12 = 4\frac{1}{2}$; so it will be necessary to distribute the remaining six coils equally around the stator. In this case every other group would have five coils, and the grouping would be as follows: 4, 5, 4, 5, 4, 5, 4, 5, 4, 5, 4, 5. This arrangement will give 18 coils per phase in a well-distributed winding.

The connection of the stator winding should be changed to single delta, which would be the proper connection for approximately 205 volts. Although the 220-volt line will cause the windings to operate at 7 per cent overvoltage, this voltage is near enough for practical purposes. The accompanying illustration shows how the coils should be connected and the number of coils per group.

GRADY H. EMERSON.
Birmingham, Ala.

REGARDING C.R.'s question, the six-pole, 10-hp. motor can be reconnected two-parallel star for four poles, 220 volts and 11 hp., using 12 groups of four and five coils per group, as, 4-4-4, 5-5-5, 4-4-4, 5-5-5. This reconnection can be worked out as follows:

The change desired is from six to four poles, or from 1,200 to 1,800 r.p.m. As an increase in speed affects the voltage and horsepower in direct proportion to the speed increase, the new line voltage should be $220 \times (18 \div 12) = 1.5 \times 220 = 330$ volts. Then the new rating will be $1.5 \times 10 = 15$ hp.

The above does not take into consideration the chord factor for both windings. For the six-pole winding the pitch is 1-and-8, which is chorded two slots as full pitch equals $54 \div 6 = 9$, or 1-and-10. Now the chord factor for the six-pole winding can be worked out as follows: 180 deg. $\div$ 9 = 20 deg., $20 \times 7 = 140$ deg., $140 \div 2 = 70$, and the sine of 70 deg. = 0.93969.

As this same winding is to be reconnected for four poles, the chord factor for the same winding, grouped for four poles, will be less than given above. It can be worked out thus:

Full pitch for 54 slots and 4 poles $= 54 \div 4 = 13.5$, or 1-and-14.5. The electrical angle between slots $= 180 \div 13.5 = 13.3$ deg. Then with the 1-and-8 pitch the electrical angle between the coil sides equals $13.3 \times 7 = 93.31$. Half this angle equals $93.31 \div 2 = 46.655$ deg. or 46 deg. 39 min. The sine of this angle is 0.72717.

If the six-pole winding had been full pitch and connected series-star, the voltage would have been $(2 \times 220) \div 0.93969 = 468$ volts. Then the four-pole, full pitch, series-star line voltage would have been $468 \times 1.5 = 702$ volts. But, as the pitch of the proposed four-pole winding is 1-and-8 and its chord factor is 0.72717, the four-pole series-star line voltage will be $702 \times 0.72717 = 510.5$ volts, or 510 volts in round numbers.

Now, if we reconnect the four-pole winding two-parallel star, the line voltage will have to be $510 \div 2 = 255$ volts. Then as the service voltage obtainable is only 220 volts, we will lose some of the horsepower rating. As the horsepower is directly proportional to the speed and torque and as the torque varies as the square of the voltage, the final rating will be lower, as $220 \div 255 = 0.8627$, or the four-pole winding voltage is 13.73 per cent too high. Then if we operate the four-pole winding on 220 volts, the torque will represent a reduction in full-load torque amounting to $(220)^2 \div (255)^2 = 48{,}400 \div 65{,}025 = 0.7443$, or 74.43 per cent.

With the speed remaining constant, the horsepower will vary directly with the torque. Consequently, the horsepower at 1,800 r.p.m., 220 volts, and with the 1-and-8 pitch will be $15 \times 0.7443 = 11.165$, or 11 horsepower. In this case, reducing the required line voltage of 255 to the service line voltage of 220 made a reduction of 13.73 per cent in voltage and a 25.57 per cent reduction in torque and horsepower.

Therefore, the present winding, if regrouped for four poles with 12 groups and connected two-parallel star, will be good for operation at 220 volts, three phase, 1,800 r.p.m. and will develop 10 or 11 hp.

The starting and pull-out torques will be higher, due to the increased rotor resistance, the iron below the slots should be sufficient, and the motor should operate satisfactorily.

A. C. ROE.
Renewal Parts Engineering Dept.,
Westinghouse Electric & Manufacturing Co.,
Homewood, Pa.

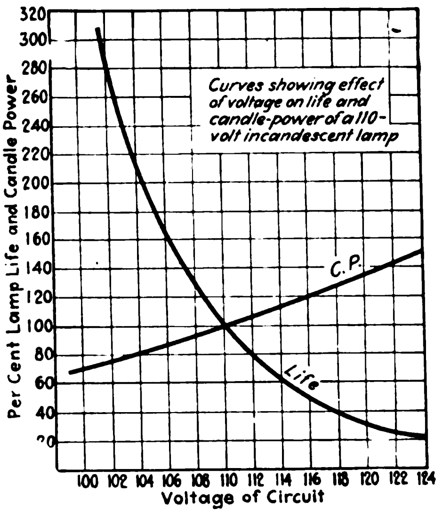
Electrical Service

AROUND THE WORKS

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Using Voltage Records to Select Proper Lamps

PRIOR to the installation of a graphic voltmeter, a plant in the industrial district of a large city was buying 110-volt lamps and getting about 50 per cent of the rated life. The lighting and power were supplied from the same feeder, but with separate transformers. However, during the day, when all the plants of the district were operating, the lighting voltage averaged 115 volts, but during the night it ran as high as 130 volts. As a result, they are now buying 115-volt lamps for all circuits except those used at night, on which 125-volt lamps are used.



Curves showing effect of voltage on life and candlepower of 110-volt incandescent lamp.

In order to determine lamp life and candlepower of 110-volt lamps at other than rated voltage, trace upward from voltage of circuit, intersecting curves. From these points of intersection, trace left to column, per cent lamp life and candlepower. For instance, 100 per cent lamp life of 110-volt lamps is shown at intersection of curves.

All this tends to substantiate the importance of the present-day incandescent lighting problem, of which cost of electricity and cost of lamps are the two most important elements. An incandescent lamp consumes its rated wattage, gives its rated candlepower and lasts its rated life only when supplied with its rated voltage. If the voltage supplied to the lamp is less than the rated lamp voltage, the candlepower and the wattage consumption are decreased and the lamp life is lengthened.

If the voltage supplied is greater than the rated lamp voltage, the candlepower and the wattage consumption are increased and the lamp life is shortened.

The balance between lamp life, light obtained and energy consumed, all of which vary with the voltage, is a rather delicate one to maintain, since the candlepower varies directly as the 3.5 power, and the life of the lamp inversely as the 13.5 power of the voltage. It is apparent, therefore, that a voltage too low for the lamp greatly reduces the amount of light obtained, and a voltage too high greatly shortens the life and increases the cost of the lamps.

In order to show what this means, the Esterline-Angus Co., Indianapolis, Ind., has computed, from data supplied by the National Electric Lamp Association, the curves of life and candlepower of 110-volt lamps when burned on circuit voltages of from 100 to 125 volts.

These curves show the necessity of knowing accurately the voltage in buying lamps, and of maintaining voltages for which lamps have been supplied. For example, a 110-volt lamp supplied at 112 volts suffers a reduction in life of 21 per cent and of 38 per cent if supplied at 114 volts.

Since the light given and the watts consumed increase with the voltage, while the lamp life is decreased, there is, depending upon the price of lamps and the price of a kilowatt-hour of energy, a relation between circuit voltage and lamp voltage rating, which will give the minimum cost of light.

Therefore, in order to buy and use incandescent lamps intelligently and economically, the voltage at which they are to be used must be accurately known. Every consumer of consequence will find it profitable to use a reliable recording voltmeter, and buy lamps of the proper voltage rating, as determined from the records of the instrument.

Simple Control to Stop Motor When Conveyor Clogs

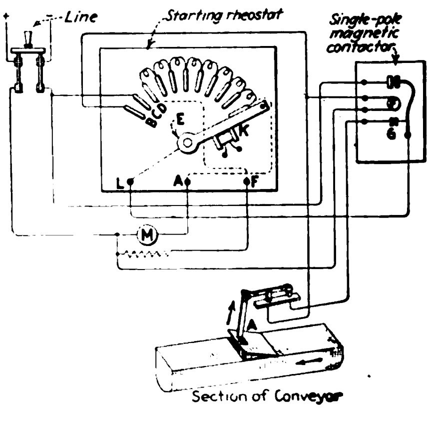
THE control system for conveyor motors shown in the illustration is in service in an Iowa plaster mill and has eliminated considerable trouble since it was installed. An explanation of the conditions under which this device operates will help the reader to understand its purpose.

A screw conveyor about 120 ft. long is used to move plaster from one building to another, the conveyor screw being 12 in. in diameter. Occasionally the bin at the discharge end of the conveyor would become filled up and cause the conveyor to stall. If the attendant was busy somewhere else at the time, either a belt or the paper pulley on the motor would be destroyed. It was finally decided to install some device to shut down the motor when the conveyor became clogged up. For this purpose, a 16-in. section of the conveyor was arranged as a hinged door opening upward. This door is shown at *A* in the illustration. It was connected to a single-pole, inclosed switch which opens when the material being handled clogs and presses against the hinged door hard enough to lift it up.

The original arrangement of the starting rheostat was changed somewhat, as shown at *B* and *C*. The resistance coil formerly connected between contacts *C* and *D*, and the spring *E* for returning the starting handle to the "off" position were removed. A single-pole magnetic contactor and the necessary wiring completed the job at a very small cost.

Assuming that the motor is idle and ready to be started, it is first necessary to bring the rheostat handle to the "off" position, thus bridging contacts *B* and *C*. This will close the circuit through the coil *F* of the contactor. The handle of the rheostat can now be moved forward to start the motor, as the contact maintaining stud *G* will keep the contactor in a closed position, if switch *A* is closed, although contacts *B* and *C* are no longer bridged. If the conveyor clogs the hinged door is pushed up, opening switch *A*, and thus breaking the circuit to contactor coil *F*.

The pressure of the material in the conveyor raises the hinged door, opening switch A, which, in turn, causes the contactor to open the motor circuit.



The contactor in turn opens the motor circuit and stops the conveyor.

In order to start again after clearing up the conveyor trouble and closing the switch at *A*, the rheostat handle must again be brought to the "off" position at *B* and *C* in order to start the motor. The low-voltage release coil, *K*, is not used, but voltage failure will cause the contactor to open, which, in turn, stops the motor.

The idea involved in this control arrangement can no doubt be modified to suit other industrial applications.

Electrician, CHAS. A. PETERSON.
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Operating Features of Automatic Charging Station for Storage Battery Trucks

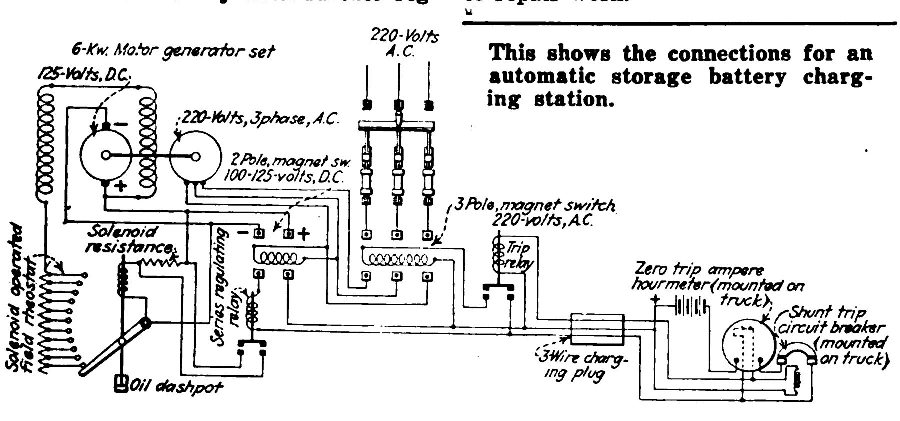
HERE are the details of an automatic battery charging station designed to meet the needs of a small manufacturer using one electric truck. It was designed to take power from a 220-volt, three-phase alternating-current circuit and to perform the following functions: First, it must start automatically when the truck driver connects the battery to the charging panel; second, it must maintain a constant current rate throughout the period of the charge, as the battery was of the nickel-iron, alkaline type; third, it must disconnect the battery in case of power failure and continue charging upon return of same; fourth, it must disconnect the battery at the completion of the charge and shut down the motor-generator set.

A 6-kw. motor-generator set was used. The normal charging rate of 38 amp. was obtained by the use of a series regulating relay and a solenoid operated field rheostat, as shown in the accompanying illustration. The series regulating relay is wound to drop its core at a current of less than 38 amp. The resistance placed in the solenoid circuit is proportioned to allow just enough current to flow to hold the core stationary. Whenever the current rate drops below normal, the series regulating relay drops its core, lowering the resistance and causes the solenoid core to rise at any predetermined speed (obtained by adjusting the oil dashpot), cutting out some of the field resistance and raising the generator voltage and charging current. When the current rate reaches the normal value, 38 amp., the relay operates, cutting in the resistance and causing the solenoid to remain stationary until further regulation of the charging is required. In operation the driver connects the battery to the charging panel by inserting the charging plug into the receptacle on the truck and pushing in the shunt trip circuit breaker. This energizes the three-pole, 220-volt a.c. magnet switch which connects the alternating-current motor to the line, and also energizes the two-pole, 100/125-volt d.c. magnet switch which connects the battery to the shunt generator. The additional torque produced by the motorized generator reduces the a.c. starting current to a value slightly above full load rating.

Again, the value of the generator field resistance is so proportioned that when the normal speed is obtained, the voltage, with all the field resistance cut in, will equal that of the battery. After the motor generator set has reached normal speed, the series regulating relay operates as outlined above, maintaining a constant current rate of 38 amp. When the ampere-hour meter indicates full charge, the zero contacts close, tripping the shunt trip circuit breaker and the trip relay, which disconnects the battery from the panel and shuts down the motor-generator set.

A station of this kind, if carefully built, will give faithful and continuous service for a long period of time. The only attention needed is an occasional inspection of contacts and working parts and oiling the motor generator set. The slightly higher first cost of construction will be overbalanced by the better operating efficiency of the battery and the elimination of an attendant while charging.

St. Louis, Mo. D. F. O'DONNELL.

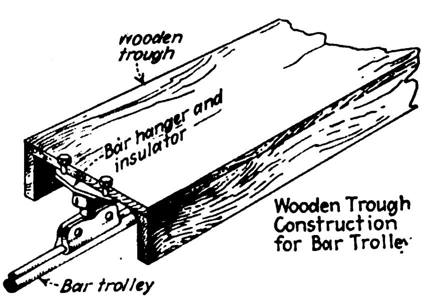


This shows the connections for an automatic storage battery charging station.

Method of Supporting Trolley Wire for Monorail Crane

A TROLLEY wire, in order to allow the wheel to ride true, must make as true an arc as possible around curves. This requires that the ears or some other method of support be spaced close together at curves and, where sharp bends are present, I would suggest that the use of trolley wire at the bends be dispensed with entirely.

It has been my experience, in such cases, that the wire becomes pitted from excessive arcing due to the wheel snapping around the bends from ear to ear. Naturally, such a condition does not do the wire or the motor any good and presents causes for production hold-ups and extra maintenance or repair work.



This bar trolley prevents the trolley from jumping and sparking at the curves.

Experience, the greatest teacher of all, reminds me to suggest the use of a bar trolley, which should be made of a suitable size and cross-section, at least equivalent in current-carrying capacity to the remaining trolley wire, and bent to the desired radius to allow the wheel to ride around the curve gradually and without any snap.

This trolley can be made up of iron bar approximately ⅝ in. thick by 1¼ in. wide and of a length sufficient to extend around the curve. Improvised insulated hangers can be used for suspending the wire, but I would suggest that regular trough-type hangers be used and that the bars be suspended under a wooden trough, as indicated in the accompanying illustration. This trough can be rigidly suspended or fastened, as local conditions would determine such a procedure.

In addition to the trough serving as a support for the trolley bar, it also protects the bar from the top, and the sides of the trough retain the trolley pole in case it should leave the trolley bar for any reason while making the curve.

NATHANIEL W. BLANCHARD.
Inwood, L. I.

Damaged Feeders Replaced Without Interruption to Production

AS THE result of a fire it was necessary for us to replace six three-phase, three-wire circuits consisting of two 350,000-circ.mil cables in parallel. Each circuit was approximately 150 ft. in length and installed in 3-in. conduits using 12 ducts in all. Our first move was to cut out one-half of each damaged and grounded circuit since they were carrying a light load. This made cutting possible.

We next set up a motor-driven hoist which had a 25-hp. motor on it for the purpose of pulling these cables, which were melted down and stuck inside of the conduit. Imagine our surprise when we broke a ½-in. steel cable four times without moving the first feeder. This was finally overcome by anchoring the conduit with ⅝-in. bolts and collars ahead of the couplings to the building beams, after which we put a heavy tension on the feeder with the hoist. We then attached a ½-ton chain block to the cable for a steady pull.

In this manner we were able to move the feeder, after which it was easy for the hoist to pull the cables out of the conduits. We attached to the far

end of the feeder a ¾-in. manila rope to pull in the new cable, but as the wire came out the insulation was stripped off. This insulation completely choked the duct. Until this insulation was removed from the conduit we knew it would be impossible to pull in the new wire.

Compressed air was used without any result, so after many schemes were considered we decided to try to melt this collection at a low place where the conduits dipped down to pass under an obstruction. This was the solution to our dilemma, although in a very unexpected way. The low place in the conduit was heated to a cherry red with an acetylene torch and compressed air at 60-lb. pressure was blown in at the end of the duct. The insulation immediately took fire and burned with a fierceness that was startling. Flame came out of the ducts like a gas main on fire, but did not cause any damage, as we were in a fireproof building. This cleaned the ducts but burned up the rope, making it necessary to fish these ducts again, which was done with a regular tape line pulling in ½-in. steel cable.

As it was necessary to keep production moving we were careful not to disturb the other circuits, which were also badly charred but still working. One complete feeder was then cut to the right length, pulled into the ducts and finally cut into service. The three other wires of this circuit were cut out on Sunday. In this way we managed to keep production up to 100 per cent and at the same time obtained a chance to replace another circuit during the week, which was cut in the following Sunday. This operation was repeated each week until the job was completed. One of these temporary feeders was made up of old wire, so that only the actual amount of wire needed was purchased for replacement. I also want to state that two ducts failed to respond to our efforts and finally were cut in two and then burned out. The total amount of 350,000 circular mil cable used was 4,985 feet, requiring the services of from 2 to 10 men as needed, the actual time charged against this job being 432 man hours. This is, I believe, the worst repair job that I ever experienced. LEO E. BENEZE.

Alton, Illinois.

Simple Limit Switch to Prevent Overtravel of Hoist

A HOIST to dump cars was recently equipped with an automatic limit switch to prevent careless operators from allowing the hoist to go beyond safe limits. This hoist is driven by a 25-hp., 440-volt, three-phase, Westinghouse slip-ring motor, which is geared 10 to 1 to the 10-in. cable drum.

A piece of cold-rolled steel threaded on a lathe was screwed in a hole, drilled in the end of the drum shaft, and tapped for a U.S. standard ¾-in. bolt, as indicated at G, in Fig. 1. A traveler, C, was made to operate on the threaded rod, F, when the drum revolves. This traveler moves away from the drum when it revolves in one direction, and toward the drum when it revolves in the other direction.

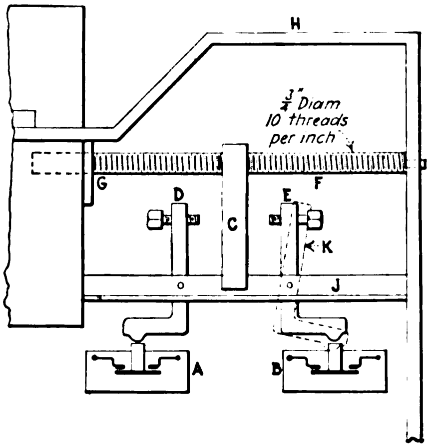


Fig. 1—This switch is used to limit the travel of a hoist by opening a contactor.

The limit stops D and E cause the contactor L, in Fig. 2, to trip whenever the drum travels too far in either direction. The setscrews shown at D and E are for the purpose of closely adjusting the limit of travel of the drum. General Electric type CR2940 BS211A push buttons are used at A and B, Fig. 1. During the normal operation of the hoist, these buttons are closed. A piece of light angle iron J was used to keep the traveler in a perpendicular position by means of a slot cut in the lower end of C sliding over one side of the angle iron. The dotted line K indicates the position of E when the button B causes the contactor L to trip.

In order to start the hoist after the automatic limit switch has tripped, it is first necessary to put the controller handle in the off position, to close the control circuit through the reset contact. This closes the circuit up to switch M. By closing the top contact of switch M, the two-pole, 60-amp., 440-volt Cutler-Hammer contactor L, Fig. 2, is made to close, if switches A and B are closed. But if switch A is open, switch A_1 must be closed and the motor started by moving the controller handle. When the traveler C, in Fig. 1, has moved far enough to allow switch

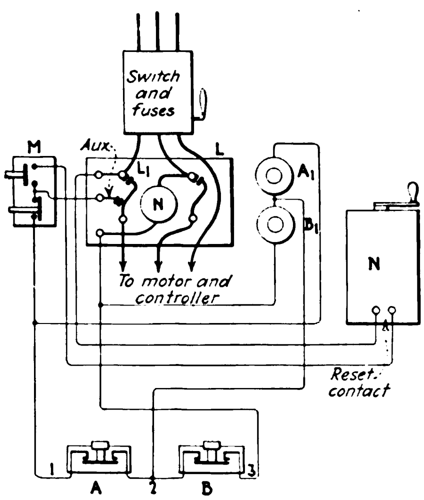


Fig. 2—This diagram shows how the limit switch, shown in Fig. 1, was connected to the motor control circuit.

A to close, then switch A_1 and the top contact of switch M can be released. Likewise B_1 allows the operator to close the contactor after it has been opened by overtravel in the opposite direction, which results in B opening the control circuit.

Whenever switches A and B have opened, the starting procedure just described must be followed out. Of course, when switches A and B are closed and contactor L is open, it will only be necessary to put the control handle in the off position and close the upper contact of switch M; then the contactor will remain in the closed position without continuing to keep the upper contact of switch M closed.

Electrician, CHAS. A. PETERSON.
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Protection of Separately Excited Generators Against Power Failure

A LARGE manufacturer of nickel-iron storage batteries has to employ several motor-generator sets used for charging and discharging new storage cells. It is necessary to do such boosting in order to take up the increasing back pressure from the cells as they become charged, meanwhile maintaining a constant rate of charge, which is much desired for this type of cell.

To simplify operation, the generator field coils were separately excited by being connected to the same source of direct current as the motor. These were protected by undervoltage and overvoltage circuit breakers. The charging line through the generator armature was protected by a modern type of reverse current breaker.

It would seem, then, that all necessary precautions had been taken against mishaps, subject, of course, to the testing out of the breakers, as was done frequently. However, when the power failed one morning, enough current backed up through the generator armature with the weak residual field to cause it to operate as a series motor running without load. The result was that in a few seconds the motor attained such speed that the armatures of both the motor and generator flew apart and were utterly ruined.

It will be noticed that for practical purposes the motor was doubly protected against power failure, for either breaker would take care of the loss or abrupt restoration of power, and so should one fail to function the other one would be awaiting its opportunity to protect the motor. The reverse current breaker was found to be in perfect operating condition. Its failure to operate properly was caused by the batteries being in such a condition of charge or discharge that they did not send back a current strong enough to operate it before excessive speed was reached. The machine is now protected with a centrifugal speed-regulating cutout designed to short-circuit the armature line across the armature as soon as the rated speed is exceeded. The reverse current breaker was left in the line to open it with the probable heavy current resulting from the short-circuit.

Orange, N. J. EDWARD MASTERSON.

MECHANICAL MAINTENANCE OF *Power Drives*

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Use of Ball Bearings on Heavy Grinding Machine

GRINDING of heavy steel machine castings subjects the bearing of grinders and their driving motors to unusually severe service. The problem of reducing bearing maintenance costs was attacked about 10 yr. ago when conversions and new installations brought the first ball bearings into service in this plant. Their dust-proof housings affected a marked reduction in maintenance costs.

The castings handled are of manganese and other steels, all for heavy machinery. Grinding operations involve the use of several types of special grinding heads designed by our company, as well as stationary and swinging grinding wheels of standard form. The unavoidable abrasive action of emery and metal dust, the heavy loads imposed, and the thrust loads encountered on the grinding heads all combined to make the type of sleeve bearings which we had been using a source of many shutdowns and considerable expense. SKF ball bearings were installed to overcome this trouble.

These bearings are well adapted to our severe working conditions and are now used extensively throughout the plant. Thirty-six grinding wheels are driven by d.c. motors, direct-connected to the wheel shafts by flexible couplings. All of these motors are equipped with these bearings. The accompanying table gives their ratings and speeds.

Number of Motors	Horsepower Rating	Type and Speeds (r.p.m.)
23	2.5	Variable 1,200/2,600
9	5	Variable 600/1,400
3	15	Constant 1,700
1	20	Constant 1,400

Also, these ball bearings are used exclusively on all special grinding heads, on many of the stationary and swinging wheel shafts, and on lineshaft drives for machine tools and freight elevators.

The types of bearings most widely used are the radial, both deep-groove and self-aligning, and the standard thrust bearing. Some of the new equipment has come standard with these bearings but a considerable number of machines have been converted to ball bearings, after previous operation with ordinary bearings.

The major advantage which we have found to result from the use of ball bearings under the prevailing operating conditions is lower maintenance cost as compared with the ordinary bearings. Ball bearings do not wear the shafting as do the ordinary bearings when they cause trouble and this has made an appreciable saving. With less maintenance and fewer bearing renewals, there are fewer delays and correspondingly increased production throughout the plant.

Another important point is that bearing renewals can be made quickly. Less oiling and inspection labor is required with ball bearings, and the cost of the lubricant required is lower. There is also a saving in power. Equipping with ball bearings motors that drive grinding wheels has reduced bearing repair costs by at least 50 per cent.

One of the outstanding cases in which the ball bearing have proved particularly valuable is on a 30-in. x 96-in. grinder. Due to the thrust load on the grinding head the old bearings, which were considered of high quality, wore rapidly, and had to be renewed frequently, causing considerable expense and serious delays. This machine is used for grinding manganese wheels, pump parts and miscellaneous rollers, and is in operation for an average of 10 hr. per day.

This problem was eventually submitted to the ball-bearing manufacturers and a plan offered to adapt the machine for ball bearings. Although some engineers claimed that ball bearings would not be satisfactory on this application, there have been no signs of trouble after more than 2 yr. of continuous operation. The bearings are in good condition and have required no attention whatever except for the regular oiling. As a result of our experience on the grinding head of this machine a 16-in. x 60-in. grinder has recently been rebuilt in the same way.

Some of the savings effected by employing ball-bearing-equipped motors to drive the grinding wheels are as follows: The saving in oiling and inspection labor amounts to $196 annually, which is a reduction of 65 per cent. Formerly the bearings had to be oiled and inspected every day, whereas now they are inspected once a week, and in many cases no new grease is added to the cups for a period of at least several months.

For the 36 grinding wheel motors so equipped, the saving in the actual cost of the lubricant amounts to $32.52 per year, a reduction of 72 per cent in this item. The saving on these two items alone is $228.52. What is still more important is the 50 per cent reduction in bearing repair costs. This is difficult to evaluate in dollars and cents because repair charges are variable, but it is estimated that this item alone amounts to between $400 and $500 a year.

Still more striking are the savings effected by equipping the 30-in. x 96-in. grinder with ball bearings. The former bearings had to be renewed after an average of one year of service and the annual replacement cost, including labor and material, amounted to at least $353.

The annual fixed charges on the cost of adapting the grinder for ball bearings amount to $79.80, but the cost of renewing the ball bearings hereafter will be no more than $60 including labor. Since the ball bearings have been in service 2 yr. and are still in good condition, it is conservative to assume the average life as 2 yr. and so make the annual replacement cost $30. Adding the fixed charges, the present annual saving effected is $243.20 in repair costs alone.

In addition, there is a saving in machine time, valued at $1.50 an hour, exclusive of the operator's wage. When the old bearings were replaced an average of 48 hr. of regular machine time was lost yearly, whereas the ball bearings can now be renewed with no more than 16 hr. lost time in a 2 yr. period. This is a net annual saving in machine time of 40 hr., which is equivalent to $60. We estimate that the total saving on the 30-in. x 96-in. grinder is $303.20 annually, or about one-half of the original cost of the changeover.

Vice-President, G. R. HANKS.
Taylor Warton Iron & Steel Co.,
High Bridge, N. J.

Precautions to Take When Installing Ball or Roller Hanger Bearings

BALL and roller lineshaft bearings have established for themselves a permanent position in industry. The saving in power, less frequent lubrication, and cleanliness are points that should not be overlooked. Tests have shown in a number of instances that the saving in power will pay for the installation in a comparatively short time.

However, there is one factor in connection with the use of such bearings that is likely to cause trouble unless care is taken in the installation. This is the problem incidental to getting bearings of the solid ring type off the shaft when this becomes necessary. Practically always the bearings are put on "to stay," because it is thought that there will be no changes made in the shaft layout. However, all industrial operating men know that practically all

assemblies that are put up to stay have to be taken down at some time. For example, a new management decides upon a shifting of machines or a general repowering; or a shaft hanger breaks, a sleeve loosens enough on the shaft to score or to allow the shaft to pound, or a solid cast-iron pulley has to be taken off the shaft. Again, perhaps some accident has been severe enough to bend the length of shaft or to crack a bearing cone.

These are some of the things which experienced maintenance men know might happen. No one can forsee them, but if any one of them did happen, one or more bearings would have to be taken off the shaft. Frequently the discovery is then made that the bearing has rusted on the shaft during its period of service.

I have found that this factor enters regardless of whether cast-iron or steel sleeves are used in contact with the shaft, or in internal contact where the parts related do not move. In a number of cases the sleeve has been rusted so tightly that it could not be removed.

In such cases it is usually necessary either to shatter the ring members so they can be picked out in small pieces or to saw off the shaft close to the bearing in order that it may be forced out in a press. A job of this kind involves taking the shaft down, whereas this would not be necessary if certain precautions had been taken at the time of installation.

Before installing bearings it is customary to wipe off the shaft and bearings so that they will be clean and dry. This leaves oil or grease only on the balls or rollers, and so the parts are put together dry in what would seem to be the best possible condition for service.

In the course of a few years it will be found that these same dry parts have rusted badly, thus creating a strong bond between parts which are already mechanically tight. This difficulty seems to be independent of the so-called "improved" designs of clamping members; it must always be considered where iron or steel parts are in contact.

The majority of men have sweaty hands, not necessarily the wringing wet kind, but exuding an unnoticed dampness that will pave the way for corrosion due to atmospheric action. Given time, rust will as surely cover the spots that the men touch as it will the finished cast-iron surface that has been marked with common chalk. The rubbing of the hands over a shaft or inside a hole as the last act of cleaning off before assembly will be the cause of rust starting.

The only way to avoid this trouble is to oil or grease all surfaces of the several parts before they are put together. Rusting takes place at the points of contact that have no relative movements. This difficulty is serious enough to merit attention from all operating and maintenance men. In the days of plain bearings it was a simple job to replace the bearings if they became worn, but ball or roller bearings are of necessity more difficult to handle. The man who has not done any of this work would naturally think that the bearing would come off with about the same amount of labor as was employed in putting it on but actually it does not.

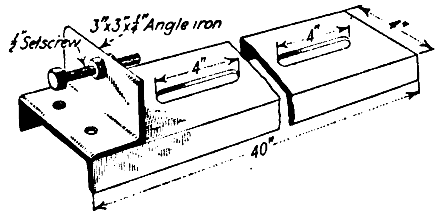
When the job of changing a bearing comes up, he gets a helper and starts to do it, thinking that he will get the job done in a few hours' overtime. However, he finds that rust has preceded him and he has to recruit his force to double the number of men and to work all night.

The new ball and roller hanger bearings have not been in use a sufficiently long time to require changing and so the difficulties of removal are not generally realized. In many cases, too, the men who have to take the shaft down do not have any idea what was the cause of this trouble, nor how to prevent it in the future.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Use of Channel Iron in Making Sliding Base for Motor

IT BECAME necessary recently to make adjustable bases for some motors that had been installed on endless belt drives without provision to take up the slack. These bases were made as shown, and found to be entirely satisfactory.



A slot was cut in the channel iron for the leg bolts of the motor, whose position is adjusted by a setscrew.

Slots 4 in. in length were cut in 4-in. channel iron to take the motor leg bolts, and a piece of 3-in. x 3-in. x ¼-in. angle iron was fastened on one end. The angle iron was tapped for a ½-in. setscrew with locknuts to force the motor back so as to tighten the belt.

Two such slides were required for each motor. The length of the channel iron, however, varied according to the dimensions of the motors.

Denver, Colo. R. M. THOMAS.

Routine for Lubrication and Inspection of Cranes

IN ONE of the largest steel plants, where the crane inspector is not a member of the crane repair gang, a weekly detailed inspection is made, usually on Friday, of all parts of hot metal and ladle cranes, and elevators. As the inspector goes along, he makes notes of anything he finds which needs attention immediately or in the near future. He carries a hammer and a short bar with which he tests the tightness of bolts and caps and checks up the amount of play in the bearings. His inspection covers every electrical and mechanical part of the cranes.

The inspectors report is typewritten; one copy is made for file, one for the superintendent of the electrical department, one for the general foreman, and one for each section foreman. If the inspector finds that any part needs immediate repair, this is reported to the foreman in charge of the works at the place where the crane is located. This report which is made by word of mouth, is noted without delay on the inspection report. Cranes other than those mentioned above are inspected by the cranemen who, while oiling their cranes, report any trouble or irregularities to their foreman.

In addition to the reports on the hot metal, ladle and heavy roll cranes, a chain and cable report is made up and carried forward each month showing the date of the last change and the number of tons or days to run until the next change. The tonnage or time allowance, as the case may be, is determined by years of experience. The ropes or chains are removed regardless of their condition at the expiration of the period. The 1½-in. chains on old ladle cranes are minutely inspected, and if repairs are necessary, they are sent to the factory which produced them to have worn links replaced with new ones.

The entire chain is then annealed and proof-tested to the original strain, and a test certificate is sent back with the chain. The chain is then held in storage for another run. Smaller chains when removed are not again used on the cranes from which they were taken. The good ends of such chains are cut off and used for slings, and the worn-out parts are scrapped.

Wire ropes that are removed from hot metal and roll cranes are never again used on these cranes. The worn or defective portions are removed from the ends, and then they are used on yard cranes where shorter lengths are employed. Ropes and chains are inspected each week by the crane inspector and their conditions noted because it has been necessary in a few cases to remove ropes before the alloted tonnage or time had been reached.

These cases were due to defects in the ropes or because of their being burned. This periodic inspection, it is believed, has prevented sudden failure and possibly damage or serious tie-up.

Lubrication of cranes is handled by the crane operators, except in extremely heavy tonnage periods when there is an oiler for the strippers and pit furnace cranes. Some of the cranes are equipped with a force-feed, grease gun system, but most of them have hand-oiled bearings with some hand-screw feed grease cups. In some parts of the works where the crane service is continuous, the operating departments provide a stated period of 20 to 30 min. for lubricating the cranes. However, they are usually lubricated when the operator sees an opportunity, which may come any time during the day. When the time for oiling is not fixed, there is frequently trouble with operating foremen who do not like to have the cranes stopped for lubrication.

D. W. BLAKESLEE.
Pittsburgh, Pa.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

How to Reduce D.C. Voltage for Testing Purposes

OCCASIONALLY it is necessary to reduce the voltage of a direct-current circuit for testing purposes, and in the absence of other suitable means of doing this a water rheostat will be found very convenient. A rheostat of this type that will be satisfactory for most purposes may be made as follows:

An ordinary oil barrel can be used for holding the water, and one rectangular plate about 1 ft. wide and 2 ft. long can be supported by a cross member at the top of the barrel. The other plate should be arranged with a pulley and counterweight so that it can be raised or lowered at will. This plate should preferably have its lower end terminating in a point, the plate becoming wider toward its upper end. The upper end of this plate should be about the same width as the other plate. The movable plate should slide between guides made of pieces of 2x4-in. wood.

With the plates mounted about 6 in. apart and the water carefully salted, a very delicate resistance control can be obtained. It should be remembered, however, that the resistance of the solution varies greatly with its temperature, and if used continuously with too small a barrel, constant adjustment and watching of the plates may be required, although an ordinary 50-gal. barrel should be fairly satisfactory for most work.

In using this method of reducing d.c. voltage, it should be remembered that any contacts in the circuit actually have to break a 110-volt current, so that if a small motor or a bell is being operated, there may be burning at the contacts.

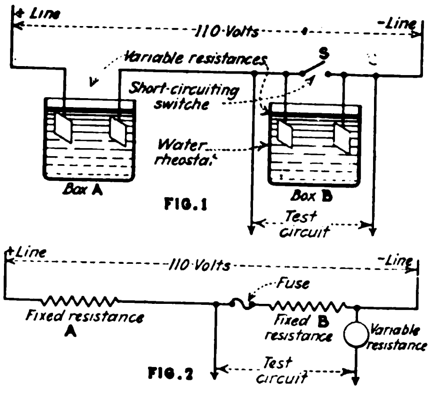
Fig. 1 of the accompanying illustration represents a means of reducing direct current that is in general a modified potentiometer method wherein two water rheostats are used. To operate this d.c. reducer, the short-circuiting switch *S* at box *B* is kept closed and the plates in box *A* are adjusted until the current flowing in the test circuit is slightly higher than the current desired. The adjustable plate in box *B* is then lowered until it just makes contact with the salt solution. While switch *S* is quickly opened and closed, the current and voltage in this circuit is noted. If the current is too high, it can be quickly lowered by adjusting box *A*, and then an adjustment in box *B* will give a finer and a closer adjustment. The advantage of this method lies in the fact that the voltage across the test circuit is only that across box *B*, so that any contact in the test circuit would break only a fraction of the line voltage in box *B*. It also allows a very easy and careful adjustment of the test line voltage, which is not possible with the single water rheostat previously described.

If it is desired to construct a permanent testing outfit, the method illustrated in Fig. 1 may be further modified by substituting either a fixed or a variable type of resistance for the water rheostat. For instance, assuming that the current desired is from 15 to 20 amp. at 15 to 20 volts, a method similar to that shown in Fig. 2 may be used. With 20 amp. in the test circuit and 1 amp. passing through resistance *B*, the total current taken from the 110-volt circuit would be 21 amp. Assuming the test circuit to require current at 20 volts, the minimum resistance in this circuit would be about 1 ohm at 20 amp., and 1.33 ohms at 15 amp. The resistance of *B* can be made 1 ohm with a capacity of 1 amp. and a fuse should be inserted in the circuit, as shown in Fig. 2, to limit the current to the set value. The resistance value of *A*, in order to allow 21 amp. to flow, must be the difference between the joint resistance of the test circuit and *B*.

Then the total resistance across the 110-volt circuit is 110 volts $\div$ 21 amp. $=$ 5.23 ohms, and the joint resistance of *B* and the test circuit with 20 amp. flowing would be $20 \div 21 = 0.95$ ohm. The resistance of *A* would, therefore, have to be $5.23 - 0.95 = 4.28$ ohms. With the test circuit disconnected and the 110-volt supply still connected, the current taken from the line would be $110 \div (4.28 + 20) = 4.53$ amp. It may often be best to have a fixed resistance at *A* and *B* and then insert a variable resistance in the test circuit. The latter resistance need be only about 0.5 ohm with a current capacity of 20 amp. The fixed resistances can readily be purchased or made up of resistance wire of the Nichrome or Climax type, preferably, as their change in resistance due to temperature is not great.

Two simple methods of reducing direct current voltage for testing purposes.

The diagram in Fig. 1 shows how a test circuit should be connected to two water rheostats that are connected in series. In Fig. 2, a variable resistance in the test circuit can be used in conjunction with two fixed resistances, *A* and *B*.



A variable resistance of the slide-wire type can be made up by winding bare resistance wire around an iron pipe about 1 in. in diam. and insulated with mica or asbestos, keeping the turns of wire about ¼ in. apart. This arrangement allows very close adjustment of the voltage. Fixed resistances that are made up so that they can be screwed into a receptacle are available on the market. These may be arranged in series or multiple groups to give any desired range of fixed resistance for any low current values. The proper size of resistance wire for the current to be carried can be obtained from the manufacturer's catalog.

C. OTTO VON DANNENBERG.
Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

Unusual Behavior of Motor Due to Design

THE following experience caused much unnecessary trouble and discussion on an overtime job that required the rewinding of the stator and rotor of an induction motor.

The rotor coils were made of strap copper, three turns per coil, the copper being bent on edge. A complete group had been made at one time without cutting the copper, which reduced the number of soldered joints to a minimum, as there was only one starting and one finishing lead for each group.

After the rotor was stripped, the coils were removed carefully so as to keep them in shape. Then all the coils were retaped with one half-lapped layer of 0.007-in. cotton tape, not treated.

The rotor was rewound and connected and when the motor was assembled the brushes were lifted to open the rotor circuit. Current was applied to the stator winding to make a balance test, and while the stator winding was excited, the shaft of the rotor was turned slightly; to our surprise the rotor came up to speed. This would indicate that there was a shorted coil in the rotor, as an open-circuited rotor should not have any current induced in it, with a series-star connection.

We then removed the rotor and used the growler to try to locate the shorted coil, but the winding tested

clear. We next applied d.c. current, and with two needle points took a test similar to the bar-to-bar test used on d.c. armatures, by pushing the needle points through the insulation and testing across each three coil turns, but this test showed clear. So we next assembled the machine and gave it a 6-hr. full load run, checking the rotor winding at ½-hr. intervals for hot coils, but apart from a growling noise, the motor operated satisfactorily.

We had noticed that the rotor had very wide teeth, and it was our final conclusion that the width of the teeth was the cause of the trouble, as we judged that eddy currents of sufficient strength were set up in the teeth to produce enough torque to bring the rotor up to speed, if given a start.

This was proved later when the same customer sent in the spare motor, which was of the same make and type. We checked the serial number to ease our consciences.

When this machine was dismantled, we stripped the rotor and held it until the stator had been rewound. Then we put the bare rotor in the frame and applied current to the stator; when the rotor was given a start it soon came up to speed. The solution of this trouble was simple enough, but it had all parties involved guessing for a time.

A. C. ROE.
Renewal Parts Engineering Dept.,
Westinghouse Electric & Manufacturing Co.
East Pittsburgh, Pa.

Round Grooving Tool for Slot Wedges Saves Time

CUTTING the rounded grooves in slot wedges with a knife is a slow process and it is more difficult to get them even, so that the paper will be folded in the slots just as you want it. Some repair men grind the grooves in the wedges on an emery wheel, but this usually leaves a burr on the end.

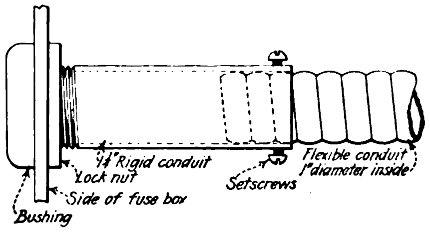
Recently, I made a gouge, as I call it, out of an old 8-in. half-round file by grinding a groove in the end on the flat side at an angle of about 45 deg. Rounding out this groove to correspond to the curvature of the back and finishing it provided a cutting edge of about the correct proportion for all slot wedges.

NICHOLAS J. WEISS.
West New York, N. J.

Method of Making End Connection for Flexible Conduit

WHEN the electricians at a plant in Michigan, which is located a long distance from any source of supplies, were called upon to connect a 1-in. flexible metal-sheathed conduit to fuse boxes it was found that there were no connectors in stock. Accordingly a few connectors were made up, similar to the one illustrated in the accompanying sketch. They were made as follows: After threading a 1¼-in. rigid conduit, a short piece was cut off with a hacksaw. Three holes for setscrews were drilled and tapped in this short piece near the end without the threads.

Preferably, these holes should be equally spaced around the conduit. On the threaded end of the connector were screwed a bushing and a locknut, and by tightening them up on opposite sides of one side of the fuse box the connector is held rigidly. After the



This connector can be made from material ordinarily kept in stock.

flexible conduit was forced into the connector from the end containing the setscrews, the flexible conduit was securely fastened in the connector by tightening up the setscrews.

This connector was not hard to make and served us well in an emergency.

Electrician, CHAS. A. PETERSON.
Fairbanks Exploration Co.,
Fairbanks, Alaska.

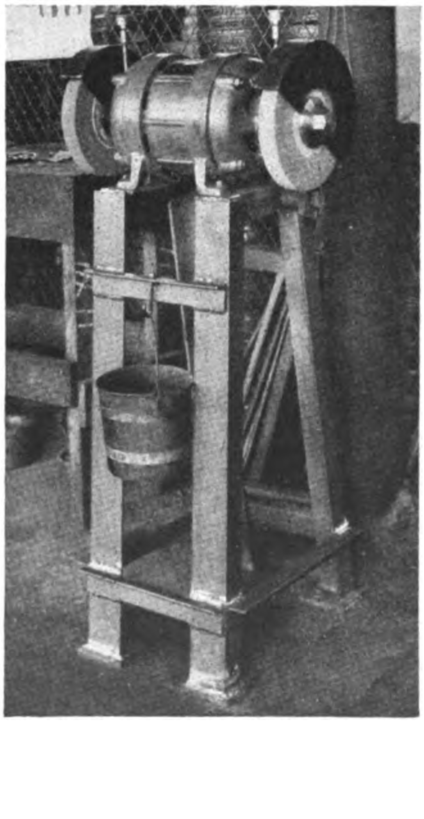
Motor-Driven Grinder Pedestal Built by Arc Welding

THE welded steel grinder pedestal shown in the illustration was recently constructed in one of the departments of the Lincoln Electric Co., Cleveland, Ohio, and shows an interesting application of the arc welding process in reducing the cost of certain types of shop equipment. When the cost was calculated it was found that this pedestal and motor complete cost less than the old belt-driven grinder with cast-iron pedestal which it replaced.

The old grinder cost $114 to put it into operation, which includes $60 to cover that portion of the lineshaft and belt chargeable to it. The welded pedestal grinder shown cost $77.60 complete, which includes the cost of 70 lb. of steel, assembled and welded with overhead on labor cost at 200 per cent.

From an operating standpoint the advantage lies with the motor-driven grinder in that its operating cost for an 8-hr. day averages about 15 cents, or $45 a year. Figured on the same basis, the operating cost of the old grinder, driven from a lineshaft, was 24.6 cents a day, or $73.80 a year. On a 10-year basis the saving in operating cost would thus amount to $288.

This grinder pedestal was built of small steel shapes by arc welding.



Unusual Motor Trouble Cause of Production Loss

RECENTLY, I found that in the course of a month I was averaging two 30-amp. fuse renewals per day in the circuit of a Type KH, two-phase, 220-volt, 60-cycle, 3,400-r.p.m. Watson induction motor that was driving a P. B. Yates self-feed rip saw. The rotor was fitted on one end of the saw arbor while the stator frame was fastened to the arbor bearing casting.

In cleaning this motor I noticed where the rotor had at one time rubbed the stator core. Upon investigation I learned that the babbitt in the arbor bearings had worn and the mechanic in charge of taking up bearings had neglected to lower the stator of the motor accordingly. The rotor eventually reached the point of contact with the stator core, producing heat enough to char the wedges in the stator slots as well as the insulation of the coils. I noticed that some of the coils were bare, and upon testing with a lamp, this being the only available equipment, I was surprised to find no indication of a ground.

I reassembled the motor after cleaning and put it into service once more; this, however, did not eliminate the blowing of the fuses. I continued to give this motor a good deal of attention; so one day after I had replaced a fuse it came to my mind that I had read an article in INDUSTRIAL ENGINEER some months ago, treating on the surging of coils under load. I concluded that these damaged coils under the charred wedges were surging, or that the charred insulation was permitting miniature arcs to jump from one strand of the coil to the other, increasing the current in that phase.

On the basis of these conclusions, I decided to balance the cost of rewinding against fuse renewals and loss to production. It was estimated that the loss in labor production per week was $13.40, on the basis of two fuse renewals per day; the operator and his helper were idle for an average of 15 min. for every fuse renewal. I also estimated that $56 would cover the cost of rewinding this stator. When these facts were placed before the superintendent, permission was granted to proceed with the job of rewinding.

This solved the problem, for the motor is now rendering efficient service. In this case, the cost of labor, fuse renewals, and production lost on this machine in one month paid for rewinding it.

E. L. WAY.
Ada, Ohio.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

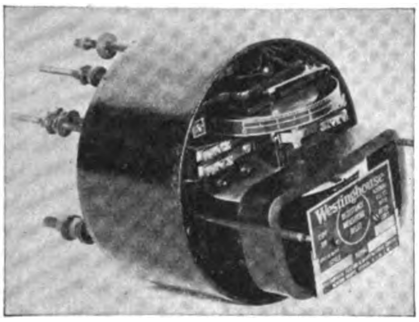
Resistance Measuring Relay

A NEW line of direct-current relays, filling an important place in this field, has been developed by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

This new X line, which includes resistance measuring, over-current voltage, polarized and relays of other types, closely resembles the Westinghouse induction-type alternating-current line of relays, and occupies about the same amount of switchboard space.

The new relays, which operate on the magnetic-vane principle, can, according to the manufacturer, have their operating values of current or voltage and their time of operation determined with a great degree of accuracy.

The resistance-measuring relay type XM has been developed for automatic service-restoring circuit-breakers and actually measures the resistance of the feeder.



Westinghouse Type XM Resistance Measuring Relay

A particular feature of the XM relay is its time limit, which prevents the breaker from pumping rapidly when the trouble is of a recurring nature. This new line of relays is particularly useful in automatic substations.

Tapered-Roller Bearings for Transmission Applications

COMPLETION of its line of power transmission equipment by the addition of a line of equipment provided with Timken roller bearings has been announced by the Medart Co., Potomac and De Kalb Streets, St. Louis, Mo. This addition consists of four units: A spherical ball-and-socket pillow block, a ball-and-socket hanger bearing of the dumb-bell or hourglass type for lineshafts, a unit mounting for incorporation into machines and special mountings or special equipment, and a loose pulley for lineshaft and countershaft usage, according to the manufacturer.

The general construction as described by the manufacturer is as follows:

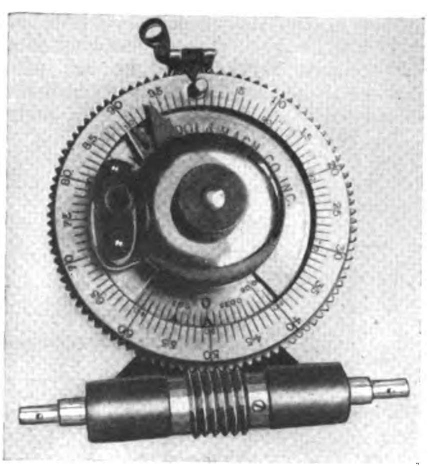
The Medart, Timken-equipped unit comprises two Timken tapered-roller bearings, assembled on a sleeve of ground steel tubing to form one unit and fitted into a finished cast-iron hub. This hub is machined to fit into a suitable housing adapted for use either in the spherical ball-and-socket pillow block, the unit mounting for building into duplicate machinery, or the loose pulley. The steel sleeve is slotted at each end and is held tight on the shaft by steel clamping collars.

Lubricant is forced into the races of the roller bearings through Alemite-Zerk fittings. Grease seals are placed in the flanges at the ends of the bearing to prevent dust from entering or lubricant leaking out. The large ends of the rolls point inward or toward the center of the bearing, which assures lubricant being pumped away from instead of toward the end inclosures, it is stated.

Revolution Stop Counter

MARKETING of a revolution stop counter involving several original design features has been announced by the Viking Tool & Machine Co., Inc., 745-759 Sixty-fifth St., Brooklyn, N. Y. This counter is for use in automatically stopping a machine after a predetermined number of revolutions, ranging from 1 to 9,750, have been made. The device is particularly applicable to various types of coil-winding machines where a fixed number of turns are to be wound, for linear measuring machines, power presses, screw machines where a limited production is required, chemical mixing machines, and textile and printing machinery.

Electric-Contact Type of Viking Revolution Counter With Automatic Stop.

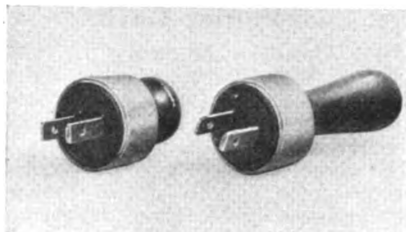


Three styles of counters are made, of which the electrical-contact type is illustrated. Stopping of a machine is accomplished by a make-and-break electrical contact that operates a suitable relay. A second type of counter is equipped with a mechanically operated plunger that operates the clutch for stopping the machine. The third style is a plain counter, by means of which the number of revolutions or strokes made by a machine can readily be determined by observation. This style of counter is limited to 9,900 revolutions; however, by means of suitable gearing between the device and the rotating member any reasonable number of revolutions above this can be counted.

The device consists essentially of a driving worm and a split wormwheel consisting of two disks. There are 100 wormwheel teeth on the periphery of the outside disk, and 99 teeth on the inside disk. The two disks are mounted on a single stud and for every 100 revolutions of the worm the rear disk advances one one-hundredth of a division over the front disk. This central stud also carries a lever for setting the predetermined number of revolutions, and for engaging a trip.

Handle Cap Plugs

MARKETING of two new designs of handle cap plugs has been announced by the Beaver Machine & Tool Co., Inc., 625-643 North Third St., Newark, N. J. These cap plugs, which differ only in the length of the handle and are shown in the illustration, are designed to replace the ordinary caps on small portable electrical equipment such as drills, gluepots, and so on.



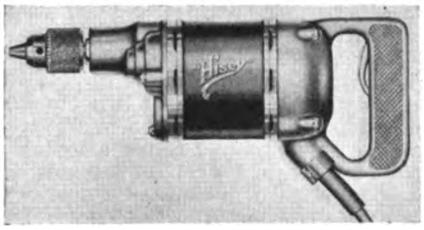
Beaver Handle Cap Plugs

The handle, which is hollow to receive the cord, is made of wood and the terminals are mounted on a molded composition base. This base is protected at the end by a nickel-plated ferrule, which also serves to hold the base and handle firmly together.

Standard-Duty ¼-In. Universal Drill

MARKETING of the new Hisey standard-duty Type 18-CU, ¼-in. universal electric drill, shown in the accompanying illustration, is announced by the Hisey-Wolf Machine Co., Cincinnati, Ohio.

Like other Hisey drills this unit is equipped with a standard electric motor of this company's design and manufacture which is said to be particularly



Hisey Type 18-CU, ½-in. Universal Electric Drill

adapted for the service. The motor is mounted on ball bearings, which in turn are fitted in a way to eliminate slip and creeping action, it is stated. Also, the gear on the armature shaft is removable. All gears are made of high-grade steel, electrically heat-treated. The compound gear shaft is supported with a bearing at each end. The Jacobs chuck, which is standard equipment, is fitted to a hardened and ground, tapered spindle. The chuck spindle is automatically lubricated through the gear case.

Including other construction features brush-holders with adjustable spring tension are mounted as a separate unit on a Bakelite yoke to facilitate brush adjustment when necessary. The end handle cover is a rugged casting which carries the pressure applied and being independent of the motor and motor bearings relieves them of strain. The automatic, quick-release-type switch is mounted in the end grip handle.

Gas Cutting Torch

THE Alexander Milburn Co., 1416-1428 West Baltimore St., Baltimore, Md., has just placed on the market a gas cutting torch for use with illuminating and byproduct gases.

The torch is constructed of bronze forgings and specially drawn tubing. The high-pressure cutting oxygen is controlled by a thumb valve, which remains fixed in either the open or closed position. The arrangement of the gas tubes, it is claimed, gives great transverse strength to the torch, which is substantially built, well balanced and easy to handle. The torch is 21 in. in length and is supplied with a complete range of tips for light, medium and heavy cutting.

A bunsen burner, contained within the torch, burns illuminating gas. This superheater, which is an outstanding feature of the Milburn torch, heats and expands the cutting oxygen, as well as the preheating gases, raising the temperature of the cutting oxygen to approximately 100 deg. C. prior to combustion, thereby increasing the temperature of the gases at the torch tip and increasing the rate of flame propagation in the burning mixture.

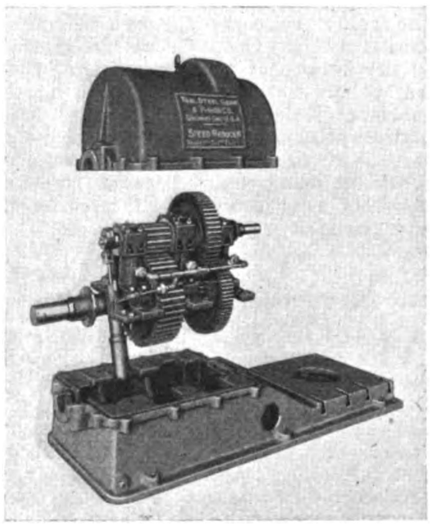
Speed Reducers

MARKETING of the Tool Steel speed reducers has been announced by the Tool Steel Gear & Pinion Co., Cincinnati, Ohio.

In the standard models plain spur gears with a 20-deg. stub tooth are used, although helical gears will be furnished, if desired, at slight extra cost. The gears are made of tool steel. All shafts are chrome-nickel steel, heat-treated and ground. Bronze bushings are used throughout, although ball or roller bearings can be supplied. These bushings are said to be of liberal design and are made of an alloy that is especially resistant to shocks and wear.

Forced lubrication to all bearings is supplied by a suction pump of simple design that is supported by the lower housing and driven by an eccentric on a slow-speed shaft. This pump, which contains no packings, springs or stem valves, will, it is claimed, handle oils ranging from the highest to the lowest viscosity. Particular care has been taken to prevent oil leaks, by a buffer joint in the lower housing and through the use of deflector rings and felt wipers in the packing boxes for the shafts.

The design of this reducer is said to be unusually rugged and compact, and particular attention has been given to accessibility for inspection or replacement of parts.



Tool Steel Speed Reducer

Flexible Shaft Coupling

DEVELOPMENT of the flexible coupling shown in the accompanying illustration has been announced by J. Y. Dahlstrand, Standard Turbine Corporation, Scio, N. Y. The coupling consists of two hubs keyed to the driving and driven shafts respectively, as shown in the drawing. One hub has externally hobbed claws somewhat similar to gear teeth, although not of a gear-tooth profile. The other hub has bolted to it an internally hobbed member of much larger diameter. In addition, there are one or more floating rings, one of which is split, with teeth on both the inside and outside circumferences that are interposed radially between the two hubs. The whole assembly is tightly closed and is lubricated by grease, injected through a connection in the side of the coupling.

The manufacturer makes the following statements concerning the coupling: It is made of steel throughout, so that it can be operated at high speed. It is free to move endwise to the extent of ½ in. without imposing any thrust on either of the rotors. It is designed to permit a considerable degree of angular misalignment and to have torsional flexibility. The coupling will also take care of a certain amount of lateral misalignment, but will transmit any load imposed, even with a considerable misalignment.

Alignment of the coupling is checked by measurement with a gage furnished with it. The coupling can be disconnected to permit operation of the prime mover without running the driven machine, or vice versa, as with duplex drives, without completely dismantling it, it is stated.

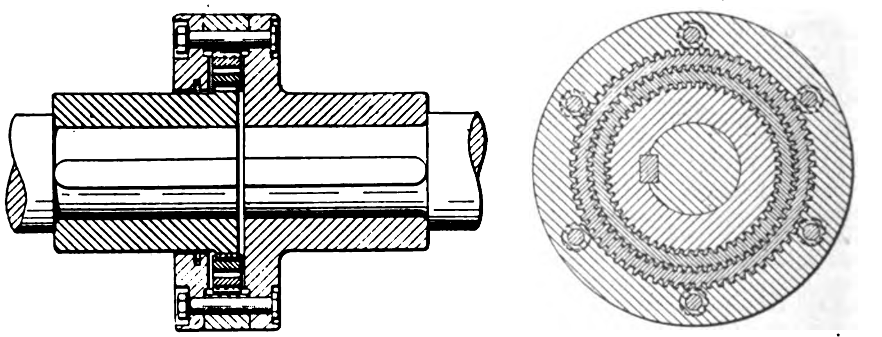
Self-Cleaning Air Filter

ADAPTATION of the Midwest principle of air cleaning to the self-cleaning type of filter has been announced by Midwest Air Filters, Inc., Bradford, Pa. This clean air filter consists of a sheet metal housing inclosing the filter chain. The filter consists of demountable cells which are arranged in an endless chain. The manufacturer states that a positive air seal and air lock have been developed at all points of contact within the chain, as well as between the filter chain and the housing.

A sediment drawer is provided at the bottom of the tank to accumulate dirt; this sediment drawer can be removed and the dirt emptied when convenient. The filter can be bolted directly to a wall or partition. The filter chain is built on the impingement principle with a viscous substance used on the cells. Operation may be on a continuous or intermittent basis. The filter chain is driven by a ¼-hp. motor with a speed-reduction unit and a silent-chain connection.

The air flow is through both sides and the top of the filter and the direction of flow may be through the duct opening or vice versa. These filters

Construction Details of Dahlstrand Flexible Coupling



are supplied in standard units with rated capacities of 10,000 to 25,000 c.f.m. Units may be arranged in multiple to obtain any desired capacity within reason.

It is stated that no operating attention is required, because the dust settles in the Viscosine tank while the cell is passing through and a fresh surface of Viscosine is constantly maintained.

Wedge-Core Unit Heater

ANNOUNCEMENT is made of the marketing of the Herman-Nelson Unit Heater by the Herman-Nelson Corporation, Moline, Ill. A view of the assembled unit is shown in the accompanying illustration. A feature of this heater emphasized by the manufacturer is that it is built to withstand steam pressures up to 100 or 125 lb. and displaces heavy pipe coils, which have commonly been used on high-pressure work. A special feature is the aluminum radiating fins on the Univent steam radiator sections. This heater is especially designed for heating factories, warehouses, garages and other industrial buildings.

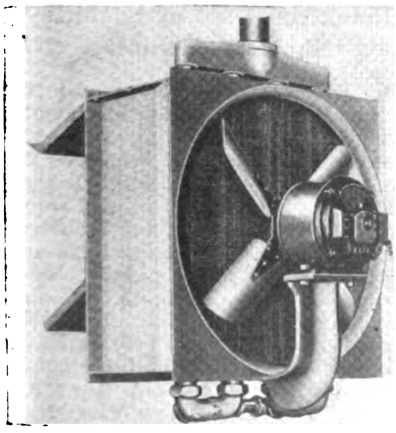
The Model 20 heater, shown here, weighs approximately 170 lb. complete with motor and louvre deflector and occupies 4 cu.ft. of overhead space. When the motor is operating at 1,150 r.p.m., it is stated that the fan on each unit will deliver in excess of 2,000 cu.ft. per min. and that at 850 r.p.m. it will deliver in excess of 1,200 cu.ft. of air per min.

It is stated also that it will operate at any steam pressure from atmospheric to 125 lb. When operating at 1,150 r.p.m., with inlet air at 50 deg. and steam pressure at 5 lb., it will deliver the equivalent of 560 sq.ft. of radiation. The same unit with inlet air at 50 deg. and with 100 lb. working steam pressure will deliver the equivalent of 960 sq.ft. of radiation.

Each unit may be automatically or manually controlled without reference to any other unit.

The radiator is of the extended surface type, but differs in that the core or steam way in it is cast in one piece of a special alloy and the aluminum fins are wedged on the one-piece cast core and held in a metal-to-metal contact by spring action. Likelihood of leakage is thus eliminated, according to the manufacturer.

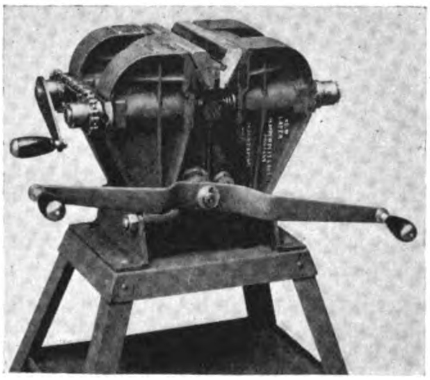
Herman-Nelson Model 20 Unit Heater



Belt Lacer

ANNOUNCEMENT has been made by the Clipper Belt Lacer Co., Grand Rapids, Mich., of the development of its new Clipper Speed Lacer, which is shown in the accompanying illustration.

This new lacer has been designed to handle belts up to 8 in. in width. It is claimed that by the use of an entirely new principle of operation, a three-quarter turn of the crank serves to apply a pressure of 45,900 lb. to the belt, embedding the hooks in perfect alignment and flush with the surface, so that wear on the pulleys is reduced to the minimum and the life of the joint prolonged. It is stated that the smallest belt may be laced by means of this tool with increased speed and economy.



New Clipper Speed Lacer

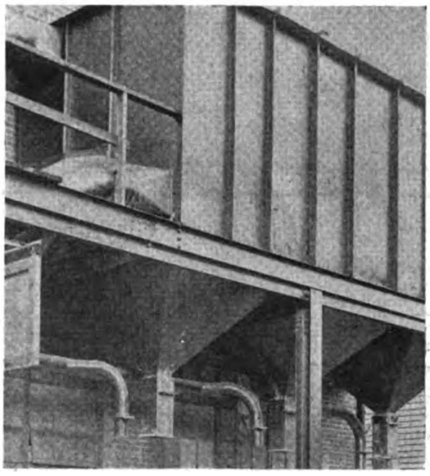
Cloth Screen Dust Collecter

NEW features have recently been incorporated in all Norblo dust-collecting equipment manufactured by the Northern Blower Co., Cleveland, Ohio.

The cloth screens in these dust collectors not only are stretched on wooden frames and heavily reinforced across the filtering area by steel braces and wires, but are stacked closely together; and the air, after the heavier suspended particles have been released by impact upon the baffle plates in front of the dusty air inlet, passes between the screens, through the fabric, and thence to the clean air chamber at the top.

The air baffle plates extend along the entire length of the dusty air chamber, and the dividing compartment that separates the clean air from the dusty air chamber has a walk-way or platform on its upper surface, which greatly facilitates inspection and maintenance of the screen.

To insure a thoroughly air-tight joint along the edge of the cloth, the wooden frame is provided with a deep groove into which the cloth is forced, and a superimposed layer of heavy cord and a series of nails at close intervals hold the cord and the cloth securely in position. All air leakage between the separate screens themselves is prevented by intervening wooden spacing strips alternately grooved and tongued, and packed with cloth on both sides. Moreover, air vents are made on both sides of each screen to provide ample air volume so as to keep the air-velocity at a minimum.



Norblo Cloth Screen Type Dust Arrester

New Locking Cord Connector

THE new Hubbell cord-grip locking connector with a rated capacity of 110 amp., 250 volts, has recently been announced by Harvey Hubbell, Inc., Bridgeport, Conn.

After plugging the cap into the connector, a slight turn is said to be all that is necessary to lock the two parts securely together.

The locking feature of this connector provides an extra and, it is claimed, very effective safeguard against accidental disconnection. This is of distinct advantage in industrial plants and other places, particularly where the service is unusually severe or where connectors are subjected to considerable vibration. These connectors are built for hard service, the bodies being made of a strong, black composition, while the caps are completely armored by a heavy, shield of steel which is heavily galvanized to prevent it from corroding.

Welding Lens

HIGH-GRADE welding lenses with special properties are being manufactured and distributed by Strauss & Buegeleisen, 30 Front St., Brooklyn, N. Y., under the name of Immunite. According to the manufacturers, the special properties of the lenses are: that they are absolutely optically ground and polished to exact plano and are claimed to be the best filter for injurious light rays yet devised. It is stated that this lens meets the requirements of the U. S. Navy specifications, and that it can be ordered and specified by shade numbers.

Each piece of Immunite will bear a certificate, giving its absorption of ultra-violet and infra-red rays, with the amount of visible and total energy transmitted.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Commutator Repair Equipment.—Catalog No. 7 describes the commutator slotting and grinding equipment and other motor repair accessories manufactured by this company.—Martindale Electric Co., P. O. Box 2660, Cleveland, Ohio.

Circuit Breakers—A 12-page circular, No. 1771, illustrates the construction, operation and application of the Types D-16, D-20 and D-26 circuit breakers.—The Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Maintenance—The advantages of periodic inspection of electrical equipment are set forth in a folder entitled "What Is Maintenance?"—The Maintenance Co., 449-53 W. 42 St., New York City.

Endless Belts—The proper way to make a splice or lap in an endless belt is minutely described and illustrated in a 16-page booklet.—Charles A. Schieren Co., 37 Ferry St., New York, N. Y.

Roller-Bearing Trolleys—A folder describes the Morris roller-bearing trolleys with illustrations of the construction and application and contains a list cf sizes and capacities.—Herbert Morris, Inc., Buffalo, N. Y.

Portable Elevators—Bulletin 908 describes the H.S.G. hoist together with various types of loading platforms and elevators.—Revolvator Co., 336-352 Garfield Ave., Jersey City, N. J.

Ventilating and Exhaust Fans—A series of bulletins covers the ventilating and exhaust fans and fractional horsepower motors manufactured by this company.—The Emerson Electric Mfg. Co., St. Louis, Mo.

Motor-Generator Sets—Bulletin 145 includes descriptions and illustrations of various types of motor-generator sets, with tables containing various data on them.—The Robbins & Myers Co., Springfield, Ohio.

Panelboards and Cabinets—Folder 4737 describes the J. T. and N. J. T. safety type panelboards and cabinets. It also contains a table of the ratings and capacities according to box dimensions.—The Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Small Motors—A number of special designs of fractional horsepower motors are described and illustrated in Bulletin 1126.—Janette Manufacturing Co., 556-558 W. Monroe St., Chicago, Ill.

Wire Conveyor Belts—A booklet describes and lists the various sizes of flexible woven wire conveyor belts for handling material that must be annealed, sprayed, filtered, screened, dried, moistened, cooled, steamed, or otherwise treated simultaneously with its movement on the conveyor.—Conveyor Sales Co., 1085 Broad St., Newark, N. J.

Tumbler Switches—A circular describes two new Trumbull tumbler switches for use with motors. The three-pole, surface-type switch is rated up to 2 hp., and the two-pole, flush type up to ½ hp.—The Trumbull Electric Mfg. Co., Plainville, Conn.

Trailers—An 8-page circular illustrates the various types of Clark trailers for industrial haulage and also the Clark hitch or automatic coupler.—Clark Tructractor Co., 1102 Days Ave., Buchanan, Mich.

Switchboard Meters—Bulletin 73 devotes 32 pages to a complete description of the construction as well as special features of the Sangamo alternating- and direct-current switchboard meters.—Sangamo Electric Co., Springfield, Ill.

Oil and Grease Equipment—A collection of bulletins illustrates and describes the Bennett oil and grease storage and handling equipment.—Bennett Pump Corp., Muskegon, Mich.

Preheating Torch—A circular describes Smith's preheating torches for use in connection with welding, for heating and bending metal, expanding parts, melting babbitt, drying molds, and crucibles, and similar work.—Smith Welding Equipment Corp., Minneapolis, Minn.

Dust Filter—Bulletin 181 shows with photographs and drawings the design and construction of the Whiting dust filter.—Whiting Corp., Harvey, Ill.

Babbitt—A small illustrated pamphlet entitled "Babbitt Metal Data" discusses the selection of babbitt metal and gives points to be considered in the use of babbitt for bearings, with instructions for casting the babbitt and fitting the bearings. A description of the grades of babbitts made by this company is also included.—Hoyt Metal Co., St. Louis, Mo.

Ventilating Fans—Catalog 1302 contains a list of specifications and prices on the complete line of fans manufactured by this company.—Robbins & Myers Co., Springfield, Ohio.

Welding Rod—A booklet entitled "A New Viewpoint on Metallic Arc Welding Parts" discusses the advantages of using a high-grade welding rod or wire as compared with a low-grade material by comparing the cost of the operator's time per pound of weld deposited.—Chicago Steel & Wire Co., 103d St. and Torrence Ave., Chicago, Ill.

Mechanical Brake—Bulletin 102-A describes the Clark type Three C brake for mechanical operation, such as in connection with the bridge drive of electric cranes.—The Clark Controller Co., Cleveland, Ohio.

Lift Trucks—The new model H Revolvator Liftrucks are described and illustrated in Bulletin 90-J. A table giving the dimensions of the various sizes of trucks is included.—Revolvator Co., 336-352 Garfield Ave., Jersey City, N. J.

Variable Speed Reducer—Bulletin 66 describes and illustrates a new type of speed reducer that is adapted for applications where a variation in speed is necessary. Variation in speed is obtained by manipulating a dial.—William E. Simpson, 100 Morgan Bldg., Detroit, Mich.

Gas-Welding Apparatus—Catalog 172-E describes and illustrates various types of welding and cutting apparatus.—The Alexander Milburn Co., 1416-1428 West Baltimore St., Baltimore, Md.

Architects' Specifications—A booklet covering almost any passenger or freight elevator installation is included in Warner's List of Architects' General Specifications.—The Warner Elevator Mfg. Co., Cincinnati, Ohio.

Lubricating Outfit—A number of circulars describe the G & B circular and rectangular tanks for storing and measuring lubricating oils.—Gilbert & Barker Manufacturing Co., Springfield, Mass.

Steel Melting Furnaces—Steel melting with Ajax-Northrup high frequency furnaces is described and illustrated in a leaflet.—Ajax Electrothermic Corp., Trenton, N. J.

Ball Bearings—A leaflet discusses a number of applications of ball bearings. Tables are included, that will assist in selecting and ordering the proper size of bearing.—The Transmission Ball Bearing Co., Inc., 1050 Military Road, Buffalo, N. Y.

Industrial Uses of Bakelite Shown in Exhibit

THERE is at present on tour in the central states a traveling exhibit showing the many and varied uses of Bakelite in industry. Upwards of 200 manufacturers who use Bakelite in their products are represented in the exhibit, which will cover important industrial centers in Ohio, Michigan and Indiana.

As the caravan reaches each stopping place, invitations are issued to engineers, manufacturers, and to the public at large to visit the show, which is usually held in one of the large hotels. The exhibit is under the direction of the Bakelite Corporation, New York, N. Y.

Volume 85 New York, June, 1927 Number 6

G. A. VAN BRUNT
Editor
D. H. BRAYMER
Consulting Editor

INDUSTRIAL ENGINEER

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

A. J. WHITCOMB
Contributing Editor
F. E. GOODING
G. H. FAIRBANKS
Associate Editors

Contents

Departments

Some of the Good Things in This Issue

THE iron and steel industry has been the pioneer in many important developments, and is today one of the most progressive groups in our industrial structure. Therefore, every operating man should read the first article in this issue, and find out how the leaders in the steel mills are solving their operating problems.

For those who are facing the problem of installing heavy bus work, the article by W. H. Boyce is full of practical pointers.

Old-timers in operating work, and newcomers, too, will be interested in G. E. Stack's story, on page 261, on the development of steel mill control.

Much progress has been made recently in the reclamation of lubricating and insulating oils. There is valuable information on this important subject in the article on page 267.

It is always interesting to compare some one else's methods with ours. O. C. Callow has made such a comparison easy, for beginning on page 272 he gives complete information on the organization of his department and the work handled by it.

Then, Edwin Fleischmann has some interesting things to say, on page 276, about the layout, construction and application of low-temperature electric ovens.

One of J. S. Murray's chief responsibilities is to keep the equipment in Follansbee Brothers' plant in proper operating condition. Turn to page 281 and read how he uses arc welding to build up and repair parts with the least possible delay.

In the practical departments answers are given to a good many puzzling problems.

Finally, every operating man will find much to interest him in the descriptions, starting on page 296, of new equipment that has been designed to cut operating and maintenance costs, and in the announcements of new catalogs and engineering bulletins, on page 300.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

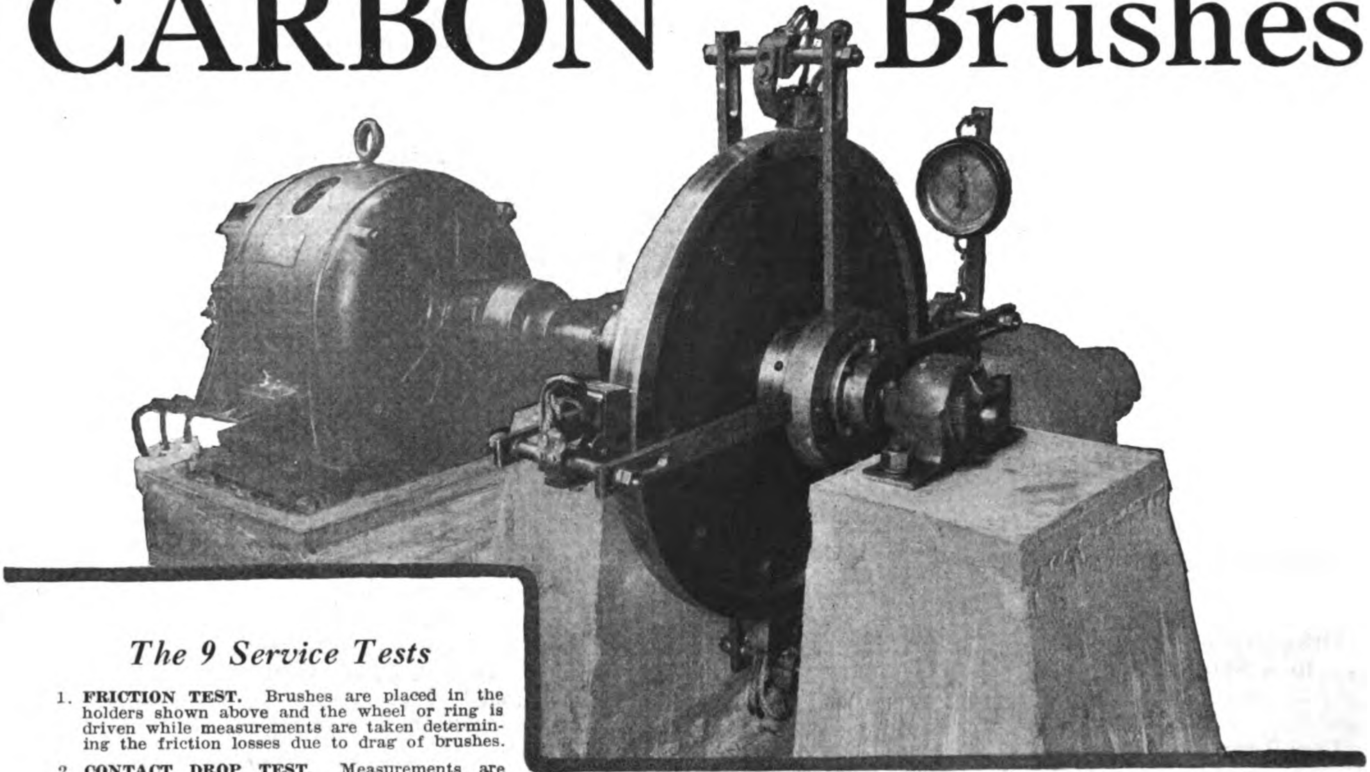
WASHINGTON, Colorado Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4
Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record — American Machinist
Power — Chemical and Metallurgical Engineering
Coal Age — Engineering and Mining Journal
Ingeniería Internacional — Electrical Merchandising
Bus Transportation — Electric Railway Journal
Electrical World — Construction Methods
Industrial Engineer — Radio Retailing
Electrical West
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.

Service TESTS for CARBON Brushes



The 9 Service Tests

1. **FRICTION TEST.** Brushes are placed in the holders shown above and the wheel or ring is driven while measurements are taken determining the friction losses due to drag of brushes.
2. **CONTACT DROP TEST.** Measurements are made to learn the loss in volts between the face of the ring and the brush under test.
3. **SATURATION TEST.** This test determines the carrying capacity of any particular grade of brush—the allowable saturation per square inch of a given brush composition.
4. **ABRASIVITY.** This machine determines the effects of various amounts of abrasive in compositions when run upon commutating surfaces in wearing away mica segments of commutator.
5. **LIFE AND HARDNESS.** Length of life in kilowatt hours per linear inch of brush is determined by running machine at a given speed with a given pressure applied to the brushes, while a potential equal to any given machine is applied to the terminals of the brushes. The amount of current flowing through a brush largely determines its speed of wearing away. Hardness is measured by the scleroscope—an instrument recording relative hardness.
6. **PERIPHERAL SPEED.** The peripheral speed in feet per minute for a given brush composition is the maximum speed at which it is permissible to operate. This involves the surface speed, the tension or pressure of the springs holding the brush on ring surface, the current carrying capacity of the brush, the draft through a machine and all other determinants of the coefficients of heat and friction.
7. **SPECIFIC RESISTANCE.** This is the resistance in ohms from one face to the opposite face of a cube whose sides are one inch long.
8. **STRENGTH.** Transverse strength is computed in pounds per square inch by a breaking test upon specimens of a uniform size.
9. **BRUSH PRESSURE.** This is given in pounds per square inch of brush contact surface. Increase in brush pressure causes an increase in friction, but gives a lower contact drop. The proper compromise of these factors is important. Get our figures for your particular needs.

One of the reasons for the increasing demand for B-B (Boxill-Bruel) brushes is that the "guess work" has been taken out before the user gets them.

There is no experimenting, no time losses, no continual replacement charge while you try to determine the right brush for the job.

The little machine illustrated tests the brushes for every operating condition and records the results for each test.

You'll find the lists of tests interesting. Read them.

BOXILL-BRUEL CARBON COMPANY
Cincinnati, Ohio

Would you like these engineering helps?—Check

Please Send Me—

- ☐ Engineering Data Sheets.
- ☐ Code Sheets.
- ☐ Compilation Sheets—Correct Boxill-Bruel Brush for Each Class Machine.
- ☐ General Catalog.

NAME ....

FIRM ....

ADDRESS ....

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 85 New York, June, 1927 *Number 6*

Trends in the application of

Steel Mill Electric Power Drives

with a discussion of present tendencies in solving problems of electrical distribution and conversion, and the use of electric heat

By ARTHUR J. WHITCOMB
Contributing Editor, Industrial Engineer

PRACTICALLY every steel mill in this country, if not already equipped with electric rolling mill drives, is either engaged in electrifying one or more mills or is considering such work. Indicative of this, there were 146 main drive motors totaling 198,240 hp. purchased during the year's period between April 1, 1926 and April 1, 1927. These motors are listed in the table on page 246.

Of these 146 motors, 90,490 hp. are of the adjustable-speed, direct-current type, 52,700 hp. are of the constant-speed induction type, 17,450 hp. are of the synchronous type, 11,200 hp. are of the adjustable-speed, alternating-current type (such as Scherbius or Kraemer), and 40,600 hp. are of the reversing, direct-current type.

Probably the most marked tendency is the rapid electrification of steam-engine-driven mills. The most extensive electrification now under way, and probably the most extensive undertaken by a large steel company, is in progress in the plants of the Bethlehem Steel Co. During the past year this company has purchased 20 motors totaling 60,850 hp., which is nearly one-third of the total horsepower of main drive motors sold during this period.

Reports from the Colorado Fuel & Iron Co., which is completing the initial part of its electrification program, state that electrification of this steel plant has resulted in a great saving of fuel, maintenance, labor and operating costs. The saving in coal alone will amount to over 150,000 tons per year, which will be further increased with the completion of the electrification. Increased production has resulted from the installation of electric drive on the mills. Every mill electrified has exceeded all previous production records. The mill speeds remain the same as formerly, the increased production being due to a more uniform mill speed being maintained than was possible with the former steam engine drive.

Six days, three and one-quarter hours was the record time made last year for the replacement of an engine drive with a reversing motor drive on a 36-in. blooming mill at the Indiana Harbor plant of the Inland Steel Co. The engine was a 50-in. x 60-in. twin simple reversing engine and was replaced by a 7,000-hp., 70/150-r.p.m., single-unit reversing motor. The work involved the dismantling and removal of the old steam engine and piping, weighing about 400 tons; blasting and excavation of 225 cu.ft. of old concrete foundations; setting of forms; pouring of 120 cu.yd. of concrete for the new motor foundation, and the assembly, connection and testing of the reversing motor drive. The use of a quick-setting cement for the new foundations permitted the motor bedplate to be set within 11 hr. after the concrete had been placed in the forms.

It is well known that, while the increasing use of electric drives has been the chief factor in reducing rolling costs and increasing production, there have also been improvements in the design of the mills that are responsible for a share of the better rolling conditions. For this reason the replacement of many wasteful steam drives is delayed until it is felt that time and funds are available to install both a new mill and an electric drive at the same time. At the plant of the Phoenix Iron Co., however, the three electric drives have been installed without any changes to the mills. The 22-in. and 24-in. mill drives have been in operation 2½ yr. and the reversing motor at the 36-in. mill for several months. It is estimated that the power cost of these devices as compared with the former steam drives has been cut in half. This, together with other savings brought about by the elimination of all steam engines, will in three years cover the cost of the electrification. In the case of the blooming mill, it is shown that electrical equipment can be fitted to an existing

mill without handicapping in any way any future mill equipment that may be purchased.

Adjustable Speed Drives—At the present time, only about 25 per cent of all of the motors installed on steel mill main drives are direct-current machines. The remaining 75 per cent are almost entirely induction motors. The wide use of the induction motor for this service is explained by its reliability of operation, ability to use alternating-current power without conversion, high efficiency, freedom from commutation troubles, low first cost and low maintenance. Adjustable-speed control can readily be obtained by the addition of Kraemer or Scherbius regulating equipment, as evidenced by the 50 Kraemer and 70 Scherbius equipments now in successful operation in this country.

Nevertheless, during the past year the number of direct-current motors purchased for main roll service is more than double the number of alternating-current motors. As a matter of fact there were sold 91 adjustable-speed direct-current motors totaling 90,490 hp. The reason for this is largely due to the development and increasing use of the modern high-speed continuous bar and strip mill with individually-driven, closely-spaced stands. On these drives accuracy of speed adjustment and regulation, with ease and flexibility of control are paramount considerations and are characteristic of the direct-current motor installations.

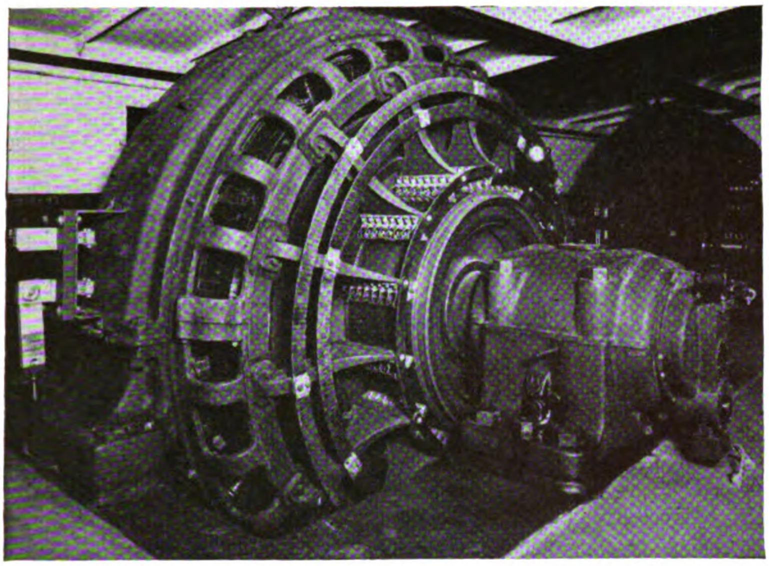
An interesting example of this relatively new type of mill with individually-driven stands, is the strip steel mill of the Columbia Steel Co. at Butler, Pa. The slabs are first rolled in a 27-in. reversing universal mill which is driven by a 5,000-hp. continuous-rated (12,500 hp. maximum), 70/150-r.p.m, 900-volt, d.c. reversing motor. After leaving the reversing mill the steel passes in succession through four stands of rolls, each of which is a four-high mill in which the working rolls are backed up by rolls of larger diameter. Each of the four stands is driven by a 2,000-hp., 200/400-r.p.m., 600-volt, direct-current motor. Power for these motors is obtained from three, 3-unit, synchronous motor-generator sets, each consisting of one 4,200-kva., 6,600-volt, synchronous motor and two 1,500-kw., 600-volt generators. The motor room for this mill is shown on page 248.

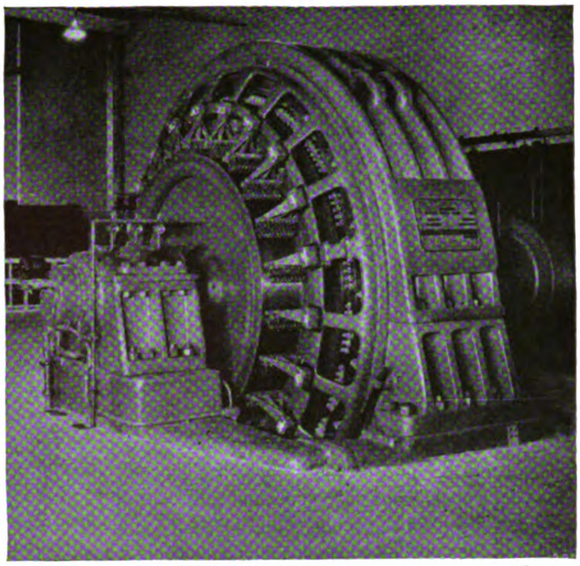
Among new installations indicating this trend toward individual

Motor-Driven Main Drives Purchased During Past Twelve Months

Company	Mill	Drive	Motors		Volts	Cycles	R.P.M.
			No.	Hp.			
Alan Wood Iron & Steel Co.	Jobbing Plate	Geared	1	1,200	2,200	25	500
	Jobbing Sheet	Geared	1	600	2,200	25	295
American Rolling Mill Co.	Sheet	Geared	1	1,200	2,200	25	244
	Bar	Geared	1	500	2,200	60	585
	Cold Roll	Geared	6	600	230	d.c.	400/800
American Sheet & Tin Plate Co.	16-in. strip mill	Geared	6	2,500	600	d.c.	160/320
	Sheet	Geared	1	2,000	2,200	60	300
	Steel Mill	....	2	1,800	2,200	25	493
	Steel Mill	....	1	350	2,200	25	485
	Cold Rolls	....	1	750	2,200	25	245
American Steel & Wire Co.	18-in. Billet	....	1	2,500	2,200	60	295
	10-in. Rod	Geared	1	3,000	600	d.c.	180/370
	10-in. Rod	Geared	2	800	600	d.c.	535/750
Babcock & Wilcox Co.	Seamless tube	Direct	2	300	230	d.c.	175/350
Bethlehem Steel Co.	12-in. Skelp	Geared	2	1,800	600	d.c.	275/550
	12-in. Skelp	Direct	1	1,100	600	d.c.	214/320
	12-in. Skelp	Direct	1	1,100	600	d.c.	246/382
	21-in. Skelp	Geared	1	6,700	6,600	25	500/250
	21-in. Skelp	Geared	1*	6,500	6,600	25	187
	21-in. Skelp	Geared	1*	4,000	6,600	25	83
	21-in. Skelp	Direct	1	2,600	600	d.c.	275/320
	152-in. Plate	Geared	1	4,500	2,200	60	450
	54-in. Blooming	Direct	1	7,000	750	d.c.	40/80
	42-in. Structural	Direct	2	7,000	750	d.c.	65/100
	42-in. Structural	Direct	2	1,500	750	d.c.	65/225
	Sheet	Geared	1	1,250	6,600	25	250
	Tin	Geared	2	1,250	6,000	25	250
	Tin Mill Cold Rolls	Geared	2	1,250	6,600	25	250
	10-in. Mill	....	1	500	250	d.c.	375/750
Bourne Fuller Co.	34-in. Blooming	Direct	1	4,000	750	d.c.	58/140
	10-in. Merchant	Geared	3	300	230	d.c.	267/800
	10-in. Merchant	Direct	4	500	230	d.c.	267/800
	10-in. Merchant	Geared	1	500	230	d.c.	267/800
Central Alloy Steel Corp.	35-in. R. Blooming	....	1	3,750	700	d.c.	50/130
Colorado Fuel & Iron Co.	25-in. Structural	Geared	1	3,000	6,600	60	450
	25-in. Structural	Geared	1	2,000	6,600	60	450
Columbia Steel Co.	18-in. Bar	Geared	1	1,500	2,200	60	322/193
Dilworth Porter Co.	10-in. Rod	Geared	1	500	2,200	60	600
Dirigold Corporation	20-in. Rolling	....	1	300	440	60	440
Ford Motor Co.	10-in. Merchant	Geared	1	800	500	d.c.	200/600
	10-in. Merchant	Direct	1	2,000	500	d.c.	137/275
	10-in. Merchant	Direct	1	1,250	500	d.c.	300/550
	Roughing	....	1	1,750	500	d.c.	100/200
	Finishing	....	1	1,400	500	d.c.	450/550
Forged Steel Wheel Co.	....	....	6	400	600	d.c.	500/1000
Gary Tube Co.	Steel	....	1*	1,500	6,600	25	62½
Illinois Steel Co.	10-in. Merchant	Geared	1	2,000	600	d.c.	315/500
	10-in. Merchant	Direct	2	700	600	d.c.	130/310
	10-in. Merchant	Direct	2	700	600	d.c.	210/660
	10-in. Merchant	Direct	1	500	600	d.c.	130/310
	10-in. Merchant	Direct	2	500	600	d.c.	150/550
	9-in. Merchant	Geared	1	1,000	600	d.c.	290/500
	9-in. Merchant	Direct	1	550	600	d.c.	336/588
	9-in. Merchant	Direct	2	550	600	d.c.	420/714
	9-in. Merchant	Geared	2	450	600	d.c.	211/422
	9-in. Merchant	Geared	4	400	600	d.c.	240/721
Inland Steel Co.	24-in. Sheet Bar	Geared	1	3,000	2,200	25	500/250
Jones & Laughlin Steel Corp.	Reversing Bar	Direct	1	3,000	650	d.c.	65/130
	Piercing	Geared	2	3,000	6,600	25	250
	Tube	Geared	1	1,500	6,600	25	375
	Tube	Geared	2	500	230	d.c.	400/800
Laclede Steel Co.	Tube	Geared	1	400	6,600	25	500
	10-in. Strip	Rope	1	1,500	600	d.c.	198/400
	10-in. Strip	Direct	1	600	600	d.c.	185/470
	10-in. Strip	Direct	1	600	600	d.c.	270/635
	10-in. Strip	Direct	1	720	600	d.c.	395/825
	10-in. Strip	Direct	1	720	600	d.c.	480/1000
Lukens Steel Co.	84-in. Tandem	Direct	1	1,200	330	d.c.	25/50
	84-in. Tandem	Direct	1	2,500	660	d.c.	53/80
Newton Steel Co.	Cold Roll	Geared	1	500	230	d.c.	400/800
Pacific Coast Steel Co.	22-in. Billet	Geared	1	2,400	2,200	60	505
South Chester Tube Co.	Tube	Geared	1	400	2,300	60	600
Standard Seamless Tube Co.	51-in. Piercing	Direct	1*	5,000	2,200	60	240
	Bar	Direct	1	2,150	535	d.c.	43/100
Suzuki & Co.	Sheet	Geared	1	1,200	2,200	60	240
	Cold Sheet	Geared	1	350	2,200	60	600
Timken Roller Bearing	Blooming	....	1	1,500	2,200	60	355
Trumbull Steel Co.	Cold Strip	Geared	1	400	230	d.c.	400/800
	Edging Rolls	Geared	1	300	230	d.c.	400/800
Washburn Wire Co.	Rod Finishing	Direct	1	1,600	2,200	60	440
Weirton Steel Co.	16-in. Strip	Geared	3	2,500	600	d.c.	200/400
	16-in. Strip	Geared	2	2,000	600	d.c.	200/400
	16-in. Strip	Geared	1	1,500	6,600	60	200
	16-in. strip	Geared	2	1,500	6,600	d.c.	450
	Cold Roll Strip	....	10	500	600	d.c.	400/500
West Leechburg Steel Co.	9-in. Strip	Geared	1	1,600	2,200	60	705
	9-in. Strip	Direct	1	800	2,200	60	505
Wheeling Steel Corp.	14-12-in. Skelp	Geared	3	2,000	600	d.c.	200/400
		Geared	1	500	600	d.c.	180/360
Youngstown Sheet & Tube Co.	Sheet	Geared	1	2,000	600	d.c.	230/460
	Seamless Tube	Geared	1*	450	2,200	60	720

* Indicates Synchronous Motor. This tabulation covers motor drives purchased between April 1, 1926 and April 1, 1927. For drives purchased prior to April 1, 1926, see page 250 of the June, 1926, issue of INDUSTRIAL ENGINEER.





More than 90,000 hp. capacity in motors of this type was purchased during the past twelve months.

These are adjustable-speed, direct-current motors used on hot strip, strip sheet, and bar mills. At the left is a Westinghouse 1,800-hp., 125/250-r.p.m. motor in the hot strip mill of the Acme Steel Co. At the right is one of the General Electric 2,000-hp. 200/400-r.p.m. motors in the strip sheet mill of the Columbia Steel Co.

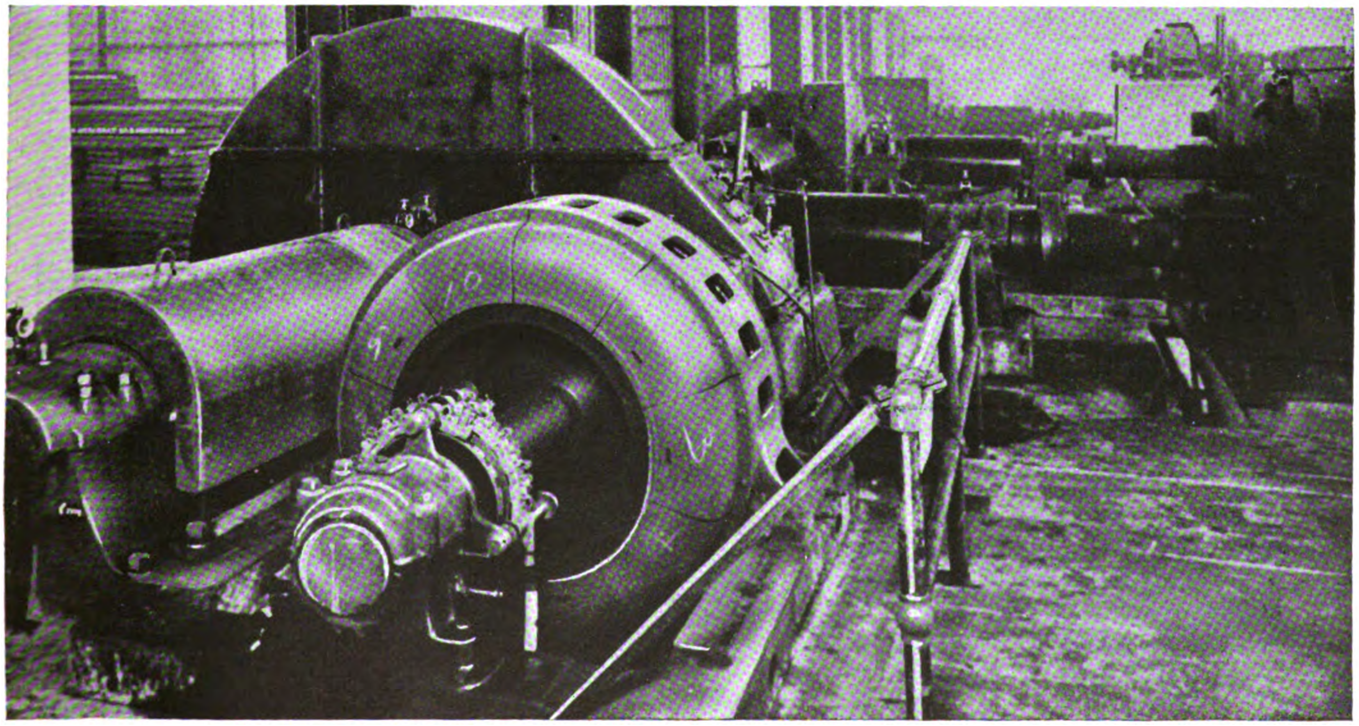
drive, there should be mentioned the 13-stand mill that will be installed by the Illinois Steel Co. at its South Chicago plant, this mill being driven by 13 motors totaling 10,500 hp. At its Gary works a 15-stand mill will have 11 motors totaling 6,500 hp., all of which are of the direct-current, adjustable-speed type.

At the plant of the Weirton Steel Co. at Weirton, West Va., a new mill is to be installed that will be driven by three alternating-current and five direct-current motors, having a total continuous capacity of 16,000 hp.

An improvement has been made in the control for tandem mill drives using separately-excited, compound-wound, direct-current motors. This consists of an adjustable rheostat in the separately excited series field which is mechanically connected to the operating mechanism of the main shunt-field rheostat so that the two rheostats are adjusted simultaneously. By the proper proportioning of resistance values the compounding excitation at all speeds may be made such that the speed change under load is less than 1½ per cent of the operating speed. The first installation using this system is said to be operating satisfactorily and several other equipments are on order.

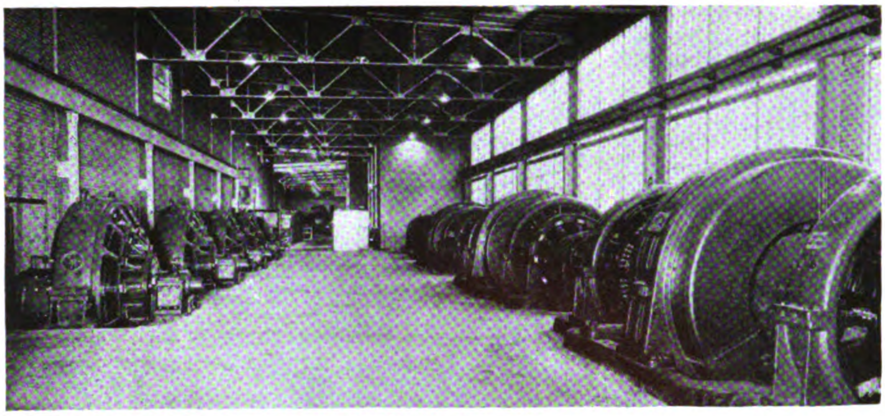
Notwithstanding the markedly increased use of direct-current, adjustable-speed, drives there is still a large demand for adjustable-speed, alternating current drives in steel mills.

An improvement in alternating-current, adjustable-speed drives has been made by the building and placing in successful operation of one 770-hp. and two 1,600-hp. equipments of the double-range, frequency-converter, constant-torque type. Speed variation is obtained by means of a frequency converter on the same shaft as the induction motor. This frequency converter is the only auxiliary rotating machine required.



Roughing stand drive in strip mill of Acme Steel Co., Chicago, Ill.

A Westinghouse 1,500-hp., 705-r.p.m., wound-rotor induction motor drives the roughing stands of a 20- 16-in. hot strip mill, through a Farrell Foundry & Machine Co. reduction gear.



Motor room of the new continuous strip sheet mill of the Columbia Steel Co., Butler, Pa.

At the right are three General Electric motor-generator sets supplying direct-current power to the four adjustable-speed, 2,000-hp., 200/400-r.p.m., motors at the left. These motors drive four-high mills in a new process for producing continuous sheets and strips.

The frequency-converter slip rings are connected to a transformer supplied with 25 cycles from the line; the commutator end of the frequency converter is connected to the slip rings of the main motor. This arrangement always gives the correct frequency to introduce into the induction motor rotor. The initial adjustment of phase position is accomplished by making the frequency converter frame so that it may be rotated slightly, and when once adjusted the frame can be doweled in position. Speeds of 10 per cent and 5 per cent above or below synchronism are obtained by taps on the transformer. At synchronous speed the induction motor rings are short-circuited. Power factor improvement up to about 100 per cent at full load is obtained by means of a tertiary winding on the transformer, supplying a small out-of-phase voltage which is added to the speed regulating voltage.

Several installations have been made of adjustable-speed, induction motors using the Kraemer and Sherbius systems of speed control. Among these there should be mentioned two unusual Kraemer drives forming part of the electrical equipment for the 21-in. sheet bar and skelp mill at the Indiana Harbor plant of the Youngstown Sheet and Tube Co. These drives are shown on page 253. The first motor is rated 3,600/1,940-hp., 290/156 r.p.m. and the second motor is rated 7,500/4,040-hp., 250/134 r.p.m. These drives are unusual in that the direct-current motor, which is a part of the Kraemer system and is ordinarily direct connected to the induction motor, is in each of these cases used as part of a synchronous motor generator which supplies power to three 2,000-hp., direct-current finishing stand motors.

The Bethlehem Steel Co. is installing at its Sparrows Point plant a continuous sheet bar and skelp mill, three stands of which will be driven by a Scherbius, speed-regulating equipment rated at 6,700/5,000/3,320 hp. at 500/365/250 r.p.m. This is the largest Scherbius-controlled, induction motor in this country.

Constant Speed Drives—Although many modern mills require application of some type of adjustable-speed drive, there are still many cases where the cheaper and more satisfactory constant-speed drives are satisfactory. Wound-rotor motors are still used in many instances, but mill operators are showing considerable interest in synchronous motors, and some applications have been made.

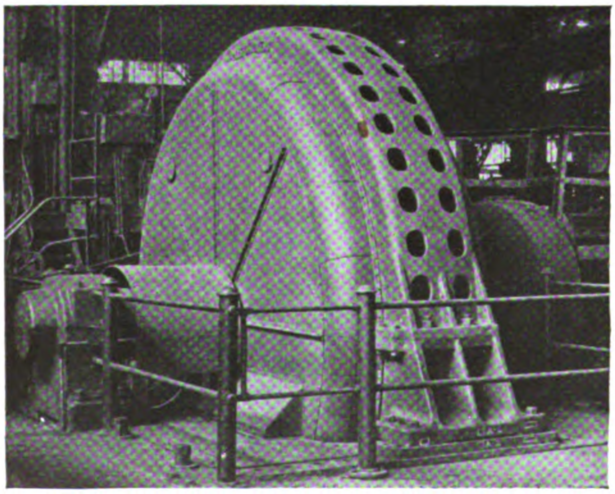
The first eight stands of the continuous sheet bar and skelp mill being built by the Bethlehem Steel Co. will be driven by two synchronous motors, one being rated at 4,000 hp., 83 r.p.m. and the other at 6,500 hp., at 187 r.p.m. A 1,500-hp., 62½-r.p.m. synchronous motor has also been installed at the plant of the Gary Tube Co.

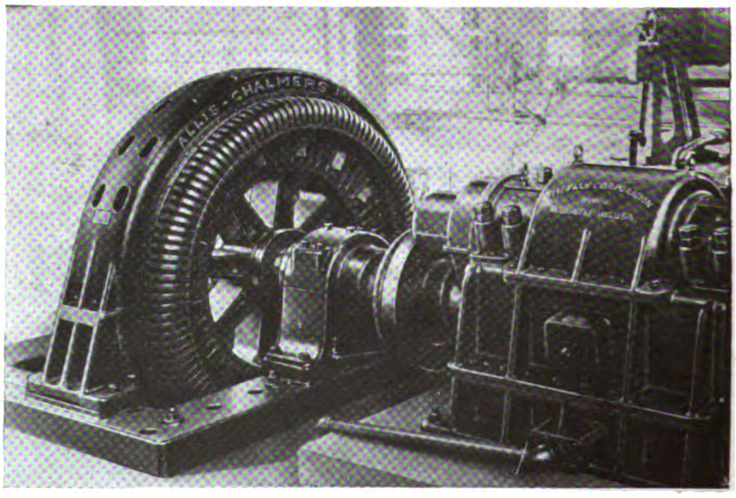
The use of the three synchronous motors on the mill just mentioned and the recent purchase of a 5,000-hp., 240-r.p.m. synchronous motor by the Standard Seamless Tube Co. for driving a piercing mill, follow the successful application and operation of the 9,000-hp. synchronous motor at the Cleveland plant of the McKinney Steel Co. This motor has now been in successful operation for about a year and is said to have met all of the demands of the mill, both in starting and running, without difficulty.

A 5,000-hp., 99-r.p.m., three-phase, 60-cycle, 13,200-volt, wound-rotor, induction motor has been built for a continuous billet mill drive. The motor is of particular interest in that it is the first mill drive built by Westinghouse for operation on higher than 6,600 volts. Also due to the

The synchronous motor is coming into its own as a constant-speed drive in steel mills.

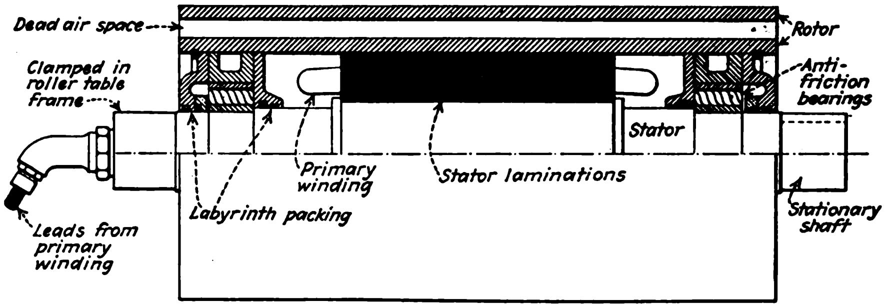
At the left is an Allis-Chalmers 1,500-hp., 6,600-volt, 62½-r.p.m. synchronous motor in a seamless tube mill at Gary, Ind. On the right is a 2,500-hp., 257-r.p.m., self-starting synchronous motor driving a piercing mill at the Milwaukee plant of the Globe Steel Tubes Co., through a Falk reduction gear.





New motor roller that has been developed in Germany.

This roller has a self-contained induction motor. The shell revolves, the central part and stator winding remaining motionless. Self-contained, anti-friction bearings support the shell.



slow speed, the motor is of exceptionally large diameter.

Reversing Mill Drives — A most important development in the last two years in the electrical equipment for reversing mill drives is the perfection of a system of parallel connections for the direct-current generator, so as to assure equal division of load under all conditions, thereby permitting the use of large single-armature reversing motors in place of the double-unit motors formerly used. During the past year there was placed in service an 8,000-hp., 40/80-r.p.m., 700-volt, single-armature reversing motor, as the drive for a 54-in. blooming mill. This is the largest single-armature reversing motor yet built. Power for its operation is supplied by two 3,500-kw., 700-volt generators operating in parallel. Six 7,000-hp., 50/120-r.p.m. 700-volt, single-armature reversing motors are now in service.

Another very interesting application of reversing motors is the use of separate motors for the main and edging rolls of the universal roughing and intermediate stands of a 52-in. structural mill. The main rolls are driven by a 7,000-hp., 50/120-r.p.m. reversing motor, and the edging rolls are driven by a 2,000-hp. 57/163-r.p.m. reversing motor. The characteristics of the motors are so proportioned that the two motors have the same inherent relative rates of acceleration and retardation. Also, the control is so arranged that the ratio of the speeds of the two motors may be changed to take care of changing roll diameters.

Application of Auxiliary Drives

STANDARDIZED Mill-Type Motors—A new line of steel mill motors, to be known as the MD-400 series, has been developed by the General Electric Co. These motors, designed in collaboration with the Standards Committee of the Association of Iron & Steel Electrical Engineers, are said to meet the specifications of that body and are the first motors on the market to do this. These motors are of the roller-bearing type, although sleeve bearings can be supplied at the option of the purchaser. A more detailed description is given on page 298.

Early this year the manufacturers and the Standardization Committee of the Association of Iron & Steel Electrical Engineers reached an agreement on the final dimensions for the Standardized Mill-Type Commutating Pole Motor. The agreement calls for seven frame sizes having the following 1-hr. or mill ratings: 7½ hp., 10 hp., 15 hp., 25 hp., 35 hp., 50 hp., and 75 hp.

For each of these sizes of motor standard over-all dimensions, standard shaft tapers and keyways, standard pinions, gears, and gear ratios, standard axle shafts, and standard anti-friction bearings have been agreed upon.

Motor Rollers—An auxiliary drive development of considerable interest is the Motor-Roller. This is a roller for use in roller tables. Instead of being geared to a lineshaft as is customary with roller tables, each roller is driven by a self-contained motor.

The roller consists of a shell or cylinder which is mounted at the ends on anti-friction bearings so as to revolve on a stationary shaft extending through the roller as illustrated at the top of this page. On the shaft between the bearings is placed the primary winding of an induction motor; this winding is on the stationary shaft in place of being in the stationary housing of an ordinary motor. The leads from this winding are taken out through the center of the shaft which is supported in a frame carrying other similar rollers so as to make a roller table. The shaft is supported outside of the bearings.

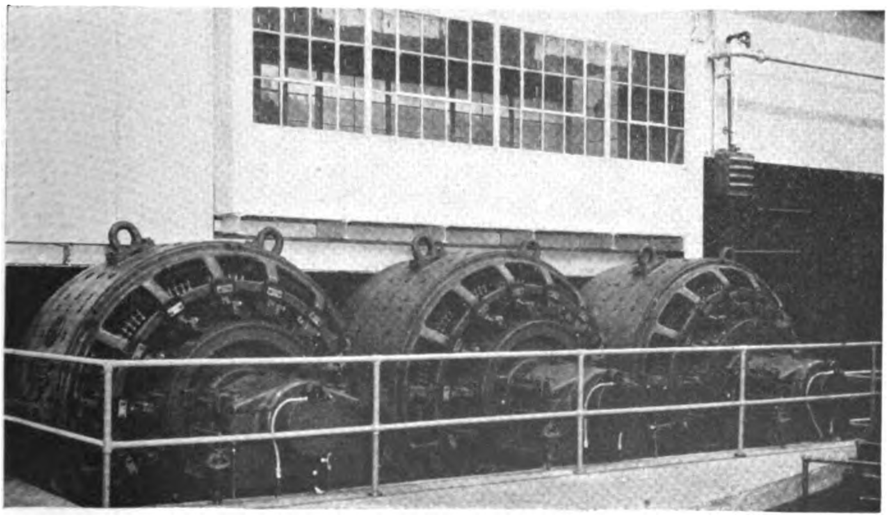
As stated in the caption above, the Motor-Roller is a German development. It is being manufactured in America by the Reliance Electric and Engineering Co. for the Schloemann Engineering Co., Pittsburgh, Pa., which is the sales representative for the device.

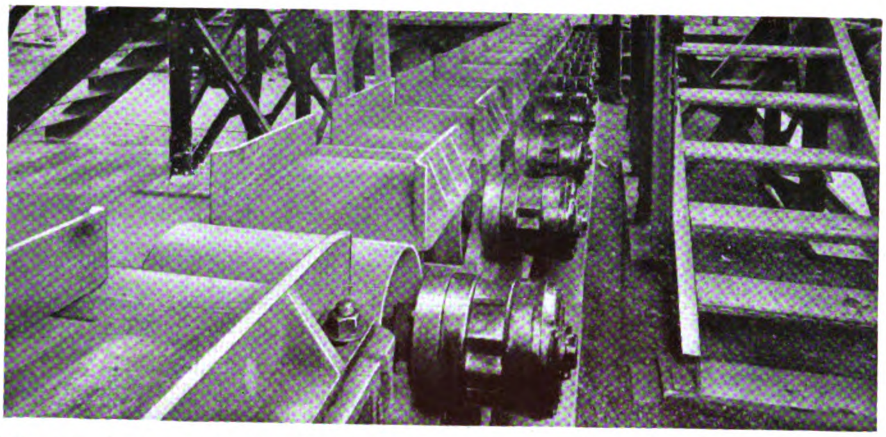
Direct-Connected Hot Saws — Direct-connected hot saws for cutting rails, shapes and the like, have recently been perfected. In the past the common practice has been to use a belt for this drive. This was due to the fact that a direct-connected motor would necessarily have to be mounted in a position normally exposed to the intense heat radiated from the metal being cut.

In the new saw, the motor and bearings are shielded from the extreme heat of the metal by a water-cooled plate or tank which is placed

Adjustable - speed, direct - current motors driving the finishing stands of a continuous sheet-bar and skelp mill.

These three 2,000-hp., 85/165-r.p.m., direct-current motors are in the Indiana Harbor plant of the Youngstown Sheet & Tube Co. This is a close-up view of the motors shown in the left background in the illustration at the bottom of page 253.





The trend is towards use of individual motor drive on table rollers.
This is the hot bed runout table in the new strip mill of the Acme Steel Co. Each roller is driven by a Westinghouse ½-hp., squirrel-cage motor running on anti-friction bearings. The bearings on the roller are also of the anti-friction type. Note that the motor is supported on one side only.

between them and the hot metal. This baffle is curved to conform to the shape of the motor frame. Water is fed to the baffle at the flywheel end of the motor and discharged against the saw.

Ward Leonard System on Ore Bridges—During the past year the Ward Leonard system of control has been used for operating ore bridges and car dumpers. A car dumper in Ohio is equipped with two 450-hp. motors on the cradle hoist and two of the same rating on the mule haul. Power is furnished through two motor-generator sets, each consisting of two 375-kw. generators, driven by a 1,100-kva. synchronous motor. The voltage of the generators is varied to control the motors by the Ward Leonard system.

* * * *

Application of Motor Control

GROWING evidence of the reduction of manpower that can be accomplished by the application of automatic control is shown in many lines of steel mill operation. Automatic charging of blast furnaces has been advanced to the point where only one man (the scale car operator) is required. This result is obtained through the use of bin gates in the stock house that can be operated by one man either by air or by means of motors, and by so sequencing and interlocking the skips, revolving top on the furnace, the small bell and the large bell, that each drive functions at, and only at, the proper time. The scale car operator selects the desired charge from the proper bins, hauls it to the skip and starts the skip on its way. The skip carries the charge to the furnace top and causes the remaining drives to function in proper succession. Several installations of this character are being considered at the present time.

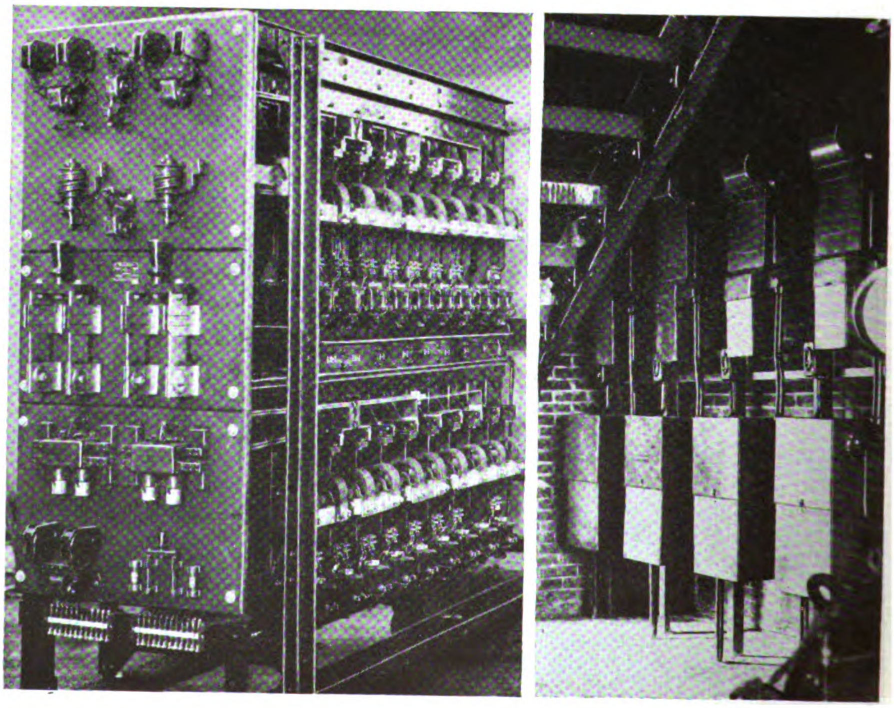
An electric stock-line recorder has been developed by the Freyn Engineering Co. for automatically recording on a chart the depth of the stock line in a blast furnace. This is of particular interest due to the fact that clever use of automatic control is utilized in its operation. At predetermined intervals usually after each dump of the big bell, a try rod is lowered by means of a motor-driven winch. The motor lowering the try rod is controlled by dynamic braking. As soon as the try rod hits the burden the dynamic current becomes zero and the automatic control is actuated to hoist the try rod to the top of the furnace where it is stopped by a limit switch. The number of revolutions made by the winch in lowering the try rod is recorded on a chart, thereby giving the blast furnace superintendent a complete record of the stock-line level for a 24-hr. period.

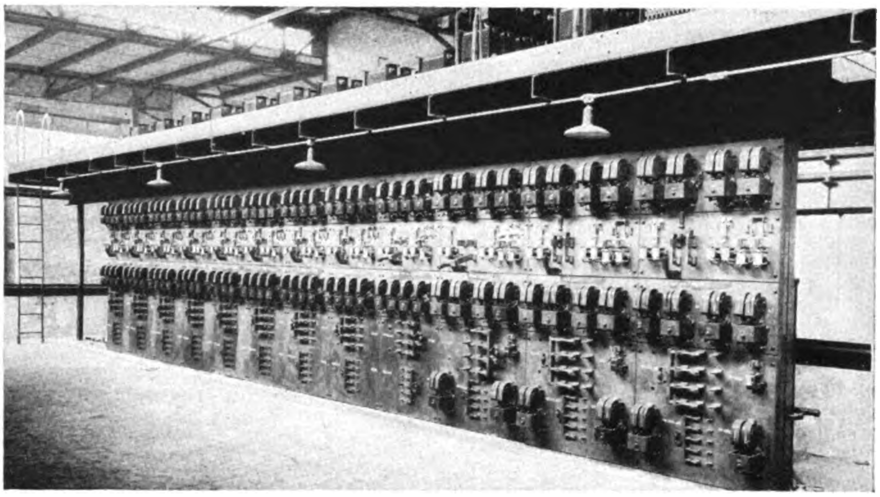
Thus it serves as a check on the frequency of filling and maintenance of stock level in the furnace. Also, it is done without the supervision of an attendant.

The installations of time-limit control are steadily increasing. Although the larger portions of these installations has been for the control of mill tables and other auxiliary drives, a very considerable number have been installed for the control of open-hearth charging machines, soaking pit cranes and standard cranes, particularly for the bridge motions. Installations of particular interest include a dynamic lowering controller for a bucket hoist and an ore bridge trolley controller. One large western steel plant has during the past year installed 75 inductive-time-limit control panels.

Aside from the familiar dashpot type, magnetic-time-limit type, and inductive-time-limit types of control acceleration, numerous devices to provide definite time for acceleration have been designed for both alternating and direct-current magnetic

Two of the newer developments in mill-type control.
At the left is the control for two 275-hp., 230-volt, direct-current motors which operate in parallel on a shear. This control is of the electro-pneumatic type and makes a complete cycle of operation every 6 sec. At the right are shown four Rowan impedance starters controlling 50-hp. pump motors in an Eastern tin mill.





Time-limit acceleration for motor control is preferred in many mills. These General Electric magnetic-time-limit panels are in the 28-in. structural mill of the Lackawanna plant of the Bethlehem Steel Co. Spare panels are provided which may be substituted for any panel in an emergency by means of the transfer switches shown on the bottom section of each panel. Notice the arrangement of resistance on a gallery.

controllers. In one form a solenoid puts spring tension on a shaft which at different angles of rotation closes successive contacts short-circuiting blocks of resistance in the motor circuit. These fingers are retarded in their closing by means of an escapement mechanism, the pendulum of which is adjusted for different time intervals. Relays using this same principle have been applied to control contactors successively cutting out resistance in the rotor circuit of slip-ring induction motors.

Improvements have been made in the control for front and back roll tables in reversing blooming mill drives. Two master switches are used, the No. 1 master rotating the tables toward the mill and the No. 2 master rotating the tables away from the mill. In normal operation only No. 1 master is used, the steel issuing on to a dead table. The No. 2 master is used only when the piece becomes long or to convey the piece away from the mill after rolling is completed. On mills with well-aligned roll table bearings, the rolls will often continue drifting from the previous pass, to such an extent that metal issuing to them on a succeeding pass will be drifted back into the mill. With the new control dynamic braking is applied to the drifting tables as soon as the other motors are energized, thus stopping the tables and preventing the metal from being returned to the mill until the master switch has been moved to the opposite position.

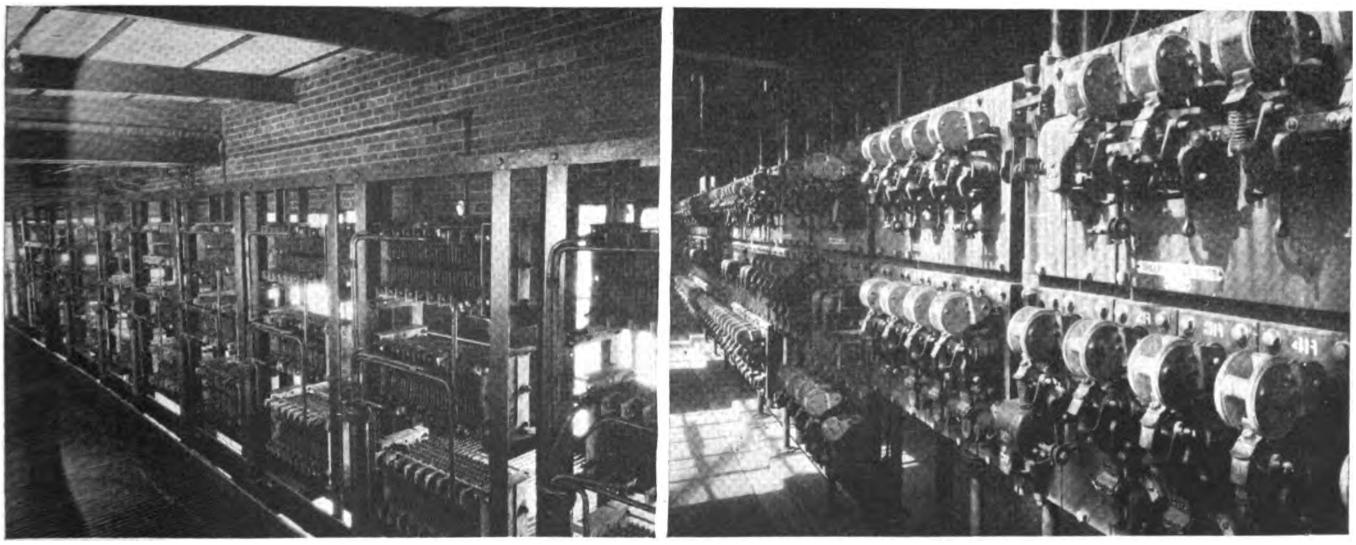
An electro-pneumatic controller has been applied to the control of two 275-hp., 230-volt, direct-current motors operating in parallel on a cutting-off machine. This controller is shown on page 250. A complete operating cycle (consisting of accelerating, cutting, braking, reverse and return to starting position), every six seconds, is made possible by this control. Magnetic contactors of the size required, would have been too sluggish for this application. In addition, the electro-pneumatic control is said to be much more compact and rugged than would have been the case with magnetic control. This controller has been operating under severe service for several months and is said to be giving very good results.

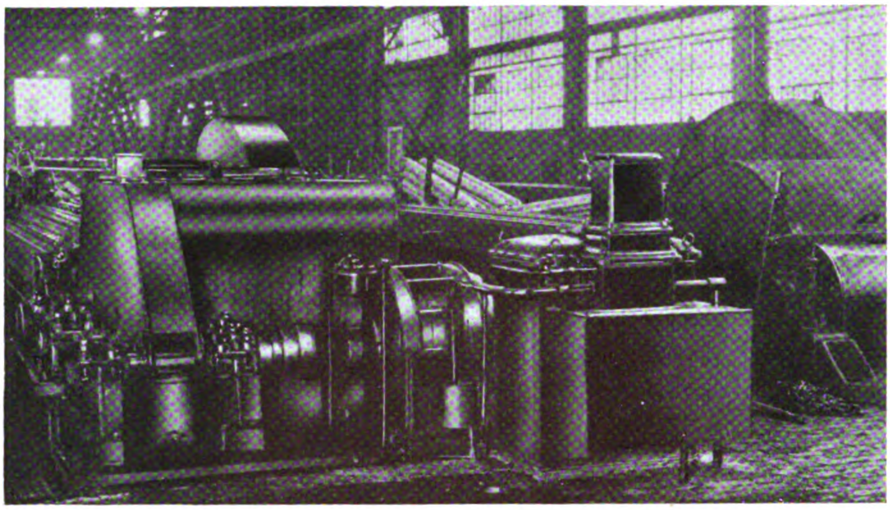
Two new magnetic brakes have recently appeared on the market. One of these, the Type WB designed by the Electric Controller & Mfg. Co., has been developed to meet the demand for a shoe-brake giving longer life of brake-shoe linings and permitting quick removal of the motor armature with the brake wheel in place, without the necessity of taking the brake apart or disturbing any of its adjustments.

An alternating-current brake has been developed by the Clark Controller Co. Due to the novel arrangement of operating levers, this brake is said to close on the brake wheel according to the spring pressure only, thereby giving no hammer blow due to the momentum of the magnet armature. The mechanical half of the brake is similar to the direct-current brake that has been manufactured by this company for the past two years.

A relatively new starter for squirrel-cage induction motors is said to

There is a trend towards the substantial installation of control. This Cutler-Hammer inductive-time-limit control is located in a control house of a large steel mill in the Youngstown district. At the left is shown the upper floor of this brick control house. Only resistors are located on this floor. Resistors are individually supported and may be removed without disturbing the others. The floor is made of iron bars so as to secure good ventilation. At the right is a view of the first floor on which the control panels are located.





Here is a synchronous motor control so enclosed and protected that it may be installed out in the mill.
This is an Electric Controller & Mfg. Co. control for a 100-hp., 2,300-volt, synchronous motor driving a drawbench. In this location it is subjected to the dirt and dust of a pipe mill.

be growing in favor for steel mill application. This starter is the Rowan impedance starter, utilizing impedance in series with the motor for starting, instead of resistance. The starter is oil-immersed, which fact is said to enable it to operate satisfactorily under the varying atmospheric conditions encountered in steel mills. A steel mill installation of these starters is shown in the illustration on page 250.

A new oil-immersed starting switch, especially designed for steel mill service has also just been placed on the market by the Rowan Controller Co. Immersing the switch in oil is said to eliminate corrosion and mechanical wear as well as give it large reserve capacity and assist the overload protection in functioning properly.

An increasing demand is noted for completely enclosed and self-contained equipment for starting synchronous motors. Equipment that has been almost standard in the past consists of a hand-operated oil switch and field switch mounted on a switchboard, suitable for substation installation. A modern installation for controlling a 100-hp., 2,300-volt synchronous motor driving a draw bench is shown in the illustration at the top of this page. As may be seen, this installation is beside the motor out in the mill.

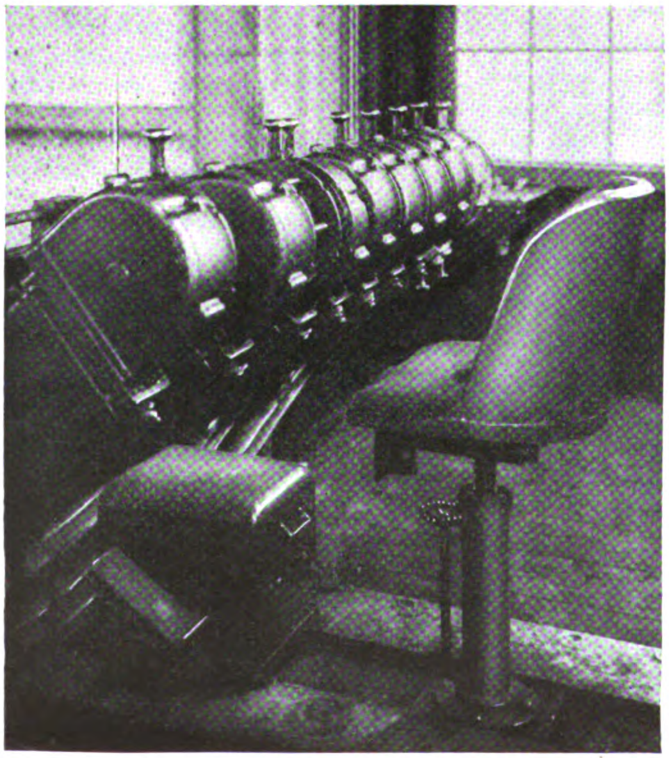
Mechanical Elements of Power Drive

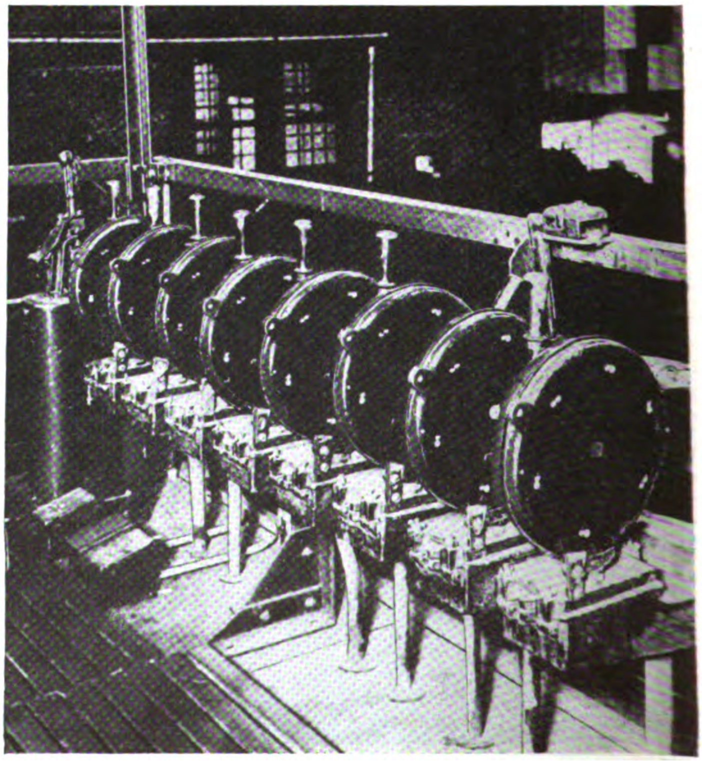
BEARINGS—It was only a short time ago that consideration was given to the application of ball and roller bearings to motors in the steel industry. Today there is practically no application in the steel plant for which the anti-friction bearing is not being considered as a possibility.

Extensive application of anti-friction bearings has been made to traveling cranes in all of the principal positions—drum shafts, backshafts, trolley and bridge trucks, reduction gears, and bridge lineshafts, to say nothing of the motor bearings. Due to their inaccessibility, bearings on cranes are very frequently neglected. Oil is not suitable as a lubricant as the motion of the crane tends to throw it out of the enclosures. Grease-lubricated bearings will run from six months to a year without attention and the possibility of oil drip is eliminated.

One mill builder advises that for some time he has been furnishing anti-friction bearings on roll tables,

Master switches with "plug-in" bases are in use in several plants.
At the left is a General Electric installation in the 35-in. structural mill at the Lackawanna plant of the Bethlehem Steel Co. By removing three wing nuts the entire master may be removed and a new one plugged in. Note the foot-operated master for controlling the main drive reversing motor. At the right is a Westinghouse installation of "plug-in" master switches.



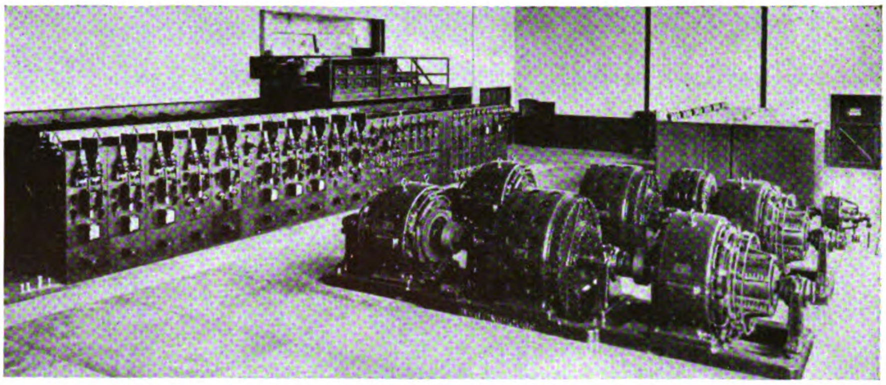


manipulators and similar steel mill applications.

Great interest is being shown in the application of anti-friction bearings to roll necks, that is, journals of rolls used in rolling steel. As early as three years ago, an installation was made in an 11-in. bar mill in the plant of Withowitz, in Czechoslovakia. This installation is said to have been very successful. Tests show that the friction load, while idling with anti-friction bearings, was 69 per cent less than that with standard bearings. In addition to the saving in power a claim is made for less change in section, resulting in less weight tolerance to be taken care of. It is also stated that very little lubrication is required, the grease being forced into the bearings mainly to insure the exclusion of water and sinter.

The Timken Roller Bearing Co. has made an installation of roller bearings in its 16-in. and 22-in. mills. This company states that a saving of power consumption is obtained, tests on the 16-in. mill showing an average of 44 per cent. This company further states that a higher grade of product can be maintained due to the greater ease of holding the sections.

There are a number of mills being put in at the present time with anti-friction bearings on the roll necks, one of the first being that built by the United Engineering & Foundry Co. for the Rome Wire Co., Rome, New York. The Youngstown Sheet & Tube Co., Lukens Steel Co., Allegheny Steel Co., Laclede Steel Co., Columbia Steel Co., Weirton Steel Co., Trumbull Steel Co., and American Steel & Wire Co., are all installing mills that will have anti-friction bearings incorporated on the roll necks.

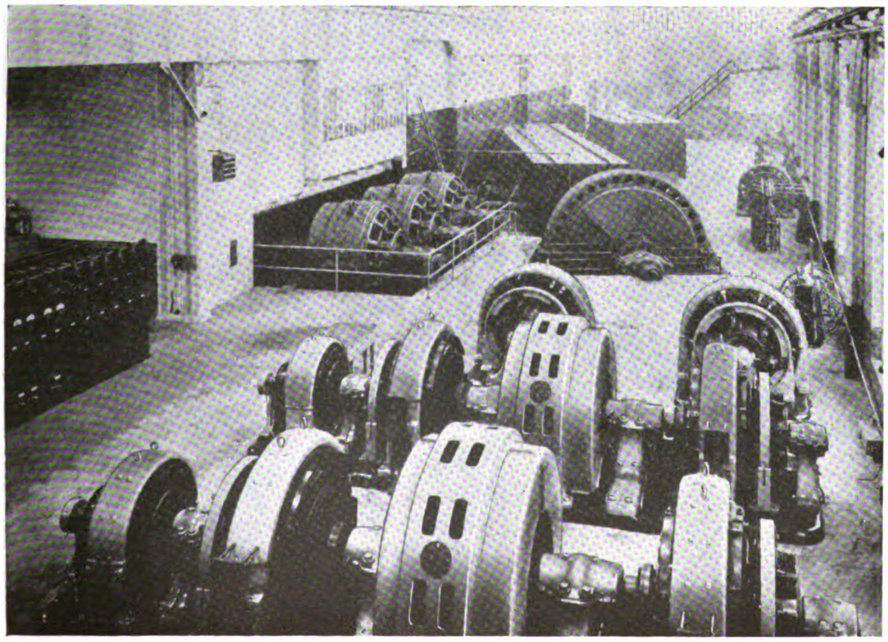


Motor rooms are becoming more elaborate and yet more compact.

Here is the motor room and substation for the hot strip mill of the Acme Steel Co. At the left are the direct-current panels for controlling adjustable-speed motors on main drives. In the center background are a.c. panels controlling truck-type switches in the right background which supply motor-generator sets at the right. This is a Westinghouse installation.

Most of the above mills are for rolling strip or sheets. Some are on four-high mills for rolling thin steel strips. One manufacturer has sold 35 such stands within the last 18 months.

Meanwhile increasing use is being made of ball and roller bearings in motors. The Youngstown Sheet & Tube Co. has changed a large number of armatures for use with roller bearings; this company has this year changed over one hundred motors so as to permit the use of roller bearings.



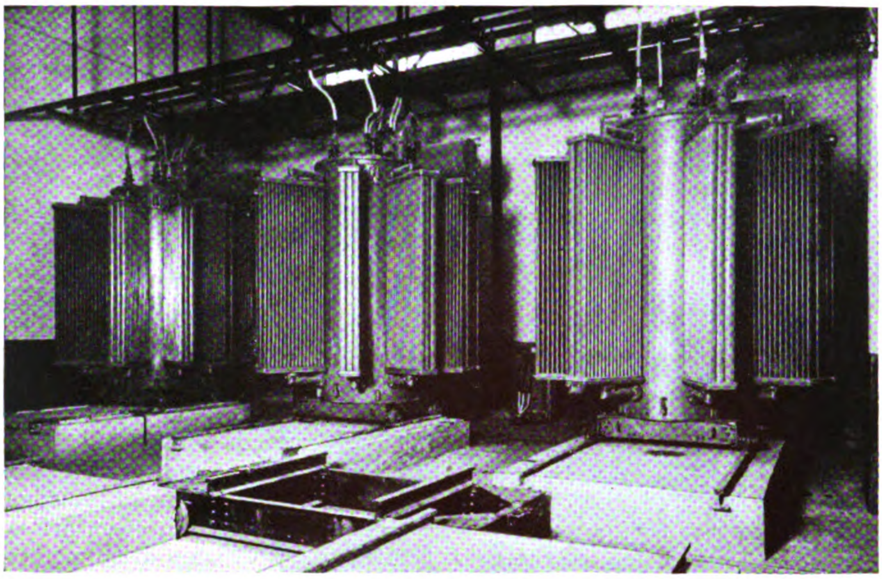
There are over 17,000 hp. in motors in this steel mill substation.

In the foreground are two motor-generator sets supplying the three 2,000-hp., adjustable-speed, main drive motors shown in the left background. In the center background is a 7,500-hp., Kraemer set. Further in the background (cannot be seen) is a 3,600-hp. Kraemer set. This equipment is in the Indiana Harbor plant of the Youngstown Sheet & Tube Co. It is a General Electric installation.

Gears—The question often arises, particularly with main drive motors, as to whether the drive should be geared or direct connected. Gearing may reduce the over-all cost and permit using duplicate motors on the various stands. A high-speed motor is generally less expensive than a slow-speed machine. At a recent meeting of the Association of Iron & Steel Electrical Engineers, H. A. Winne of the General Electric Co., stated that unless the high-speed unit runs two to three times the mill speed, its cost added to that of the gear will be more than that of the direct-connected motor. In other words, he said, unless the gear ratio can be made at least 2:1, the gear had probably better be omitted. The gear ratio will be determined by the mill speed and the maximum desirable motor speed; this latter, in turn, is fixed largely by the capacity of the drive.

Geared main drives are used to a large extent in many new steel mill installations. However, these, like many of the smaller drives, are becoming more on the order of a large speed reducer, with cast-iron cases and pressure lubrication, using filtered oil that is recirculated.

Speed reducers for smaller auxiliary drives are finding favor in all applications where a large reduction in speed as well as a compact installation are required. The Falk Corporation has brought out a new and improved line of standard speed reducers featuring continuous-tooth herringbone gears and an improved lubricating system. The Tool Steel Gear & Pinion Co. has also developed a line of speed reducers featuring their Tool Steel gears, heat-treated, chrome-nickel steel shafts and a built-in pump for supplying forced lubrication to the moving parts. The worm gear speed reducer is



Here is a typical steel mill transformer substation.

These three Westinghouse, 3,333-kva., 12,000/2,300-volt, self-cooled, transformers are in the plant of the Acme Steel Co. The transformers are permanently mounted on small trucks that may be pushed to the large truck shown in the center and then taken out of the substation.

popular in many mills. In fact several worm gear reducers have been specially developed for steel mill service.

However, there are many geared auxiliary drives where the standard speed reducer does not fit in and special gearing is required, as on mill tables, cranes, and the like. There is a distinct tendency towards total enclosure of these gears, thereby permitting them to run in an oil bath.

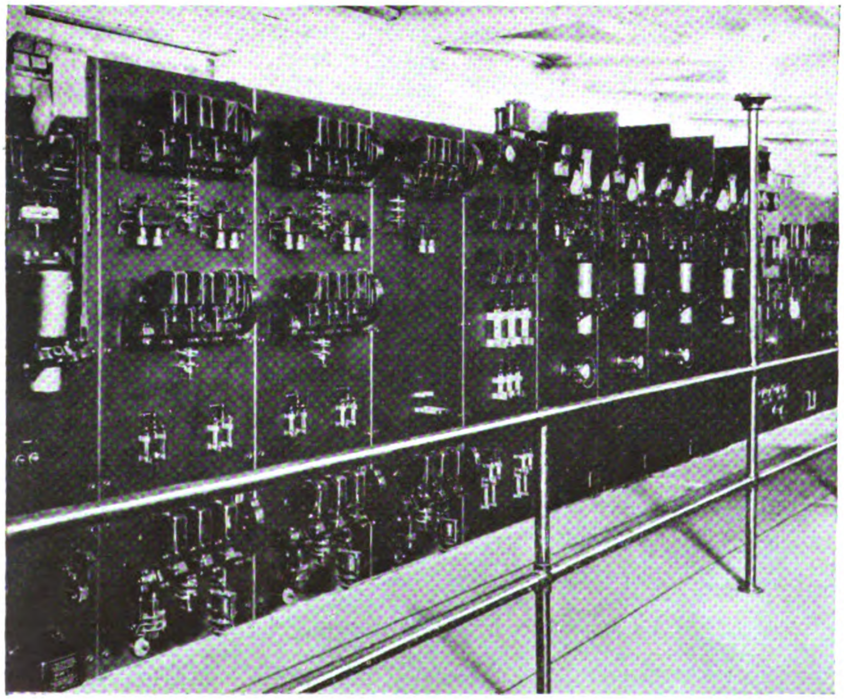
Flexible Couplings—Reversing mill motors are usually connected to the lower mill pinions by couplings of the universal or common grab type. Recently large flexible couplings were installed on two 34-in. blooming mills driven by 3,500-hp., 50/120-r.p.m. reversing motors. These motors are each capable of exerting emergency torques of 1,000,000 lb. ft. They represent, therefore, the heaviest service to which flexible couplings have as yet been applied.

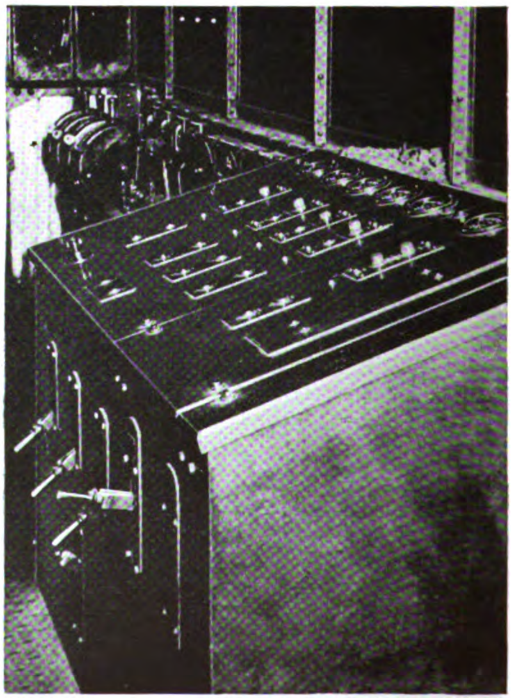
Lubrication — Forced lubrication is becoming almost the rule in new mill installations. A merchant mill recently completed in the Chicago district utilizes three Bowser oil filtering units. One unit furnishes oil to the gears and bearings on the universal mill, the second unit distributes oil to the three sets of reduction gears and bearings and also to the pinion gears and their bearings on the remaining stands of the mill, while the third unit serves the bearings on the motors and flywheel motor-generator set driving the mill. The oil used in the first two units is heavy and will congeal in cold weather. Hence, all oil lines running to and from these units are heated with low-pressure steam pipes incased in the insulation covering the oil pipes. Each receiving tank, filter, and pressure tank is provided with heating coils.

* * * *

Distribution and Conversion of Power

AUTOMATIC *Substations*—The use of automatically controlled substations in steel plants has increased very greatly since the first installation in 1924. Many plants have found automatic control so reliable that they are changing over their existing manual stations. Others are installing either complete or partial automatic equipment provided with push-button, starting and stopping stations. In some cases an operator will be maintained at these stations simply to start and stop the equipment and at other times to act as a watchman. The change is due to the demonstrated superior accuracy, rapidity, and reliability of





Switching and control panels for over 10,000 hp. in main drive motors.

These panels control the four main drive motors in the cross-country mill of the Wisconsin Steel Co. At the right is the operator's pulpit and control desk.

automatic control as compared with manual control.

One plant has considered these features as of sufficient importance to warrant the installation of automatic switching equipment for synchronous motor-generator sets and auxiliary direct-current feeders in a large *attended* substation which also houses several large structural mill drives.

The Commonwealth Steel Co. has placed in operation at its Granite City (Ill.) plant, a two-unit, automatically-controlled, synchronous motor-generator station with counter-e.m.f. regulator control. One generator is rated at 1,800 kw., and the other at 900 kw. Both furnish power at 250 volts direct current to the steel foundries of this company.

The Youngstown Sheet & Tube Co. has installed two automatically-controlled motor-generator sets in its new tin mill at Indiana Harbor, Ind. Installation of automatic substations has recently been completed by the Illinois Steel Co., Lorraine Steel Co., and others.

Switching — The advantages of truck-type switching equipment have been appreciated by many steel plant operators, and several large installations of truck-type switches are being made. The ease of replacing any damaged truck by a spare truck circuit breaker may in some cases warrant the installation of a single feeder breaker, whereas with cell-mounted breakers it is considered necessary to install duplicate apparatus to protect the service adequately.

The first isolated-phase switching equipment in an industrial plant was installed in the new generating station of the Franklin works of the Bethlehem Steel Co. at Johnstown, Pa. This initial installation was followed by others in the plants of the Illinois Steel Co. at Gary, Ind., and the Jones and Laughlin Steel Corporation at Woodlawn, Pa.

Distribution—Many steel plants have reached and passed the economic limit of 2,200 volts for distribution. The large amounts of power required by some mill drives result in prohibitive current values at this voltage. This is reflected in higher cost of protective oil switches and line losses even in the relatively short transmission distances from the load center to the numerous mill motors.

A distribution voltage of 6,600 has become quite common. The increasing loads in the larger plants, however, are taxing even the 6,600-volt systems, but so far there have been reported very few installations of main drive motors fed directly from a 13,200-volt system. One such motor rated at 5,000 hp., 99 r.p.m., has been installed on an 18-in. continuous billet mill drive at the River Rouge plant of the Ford Motor Co.

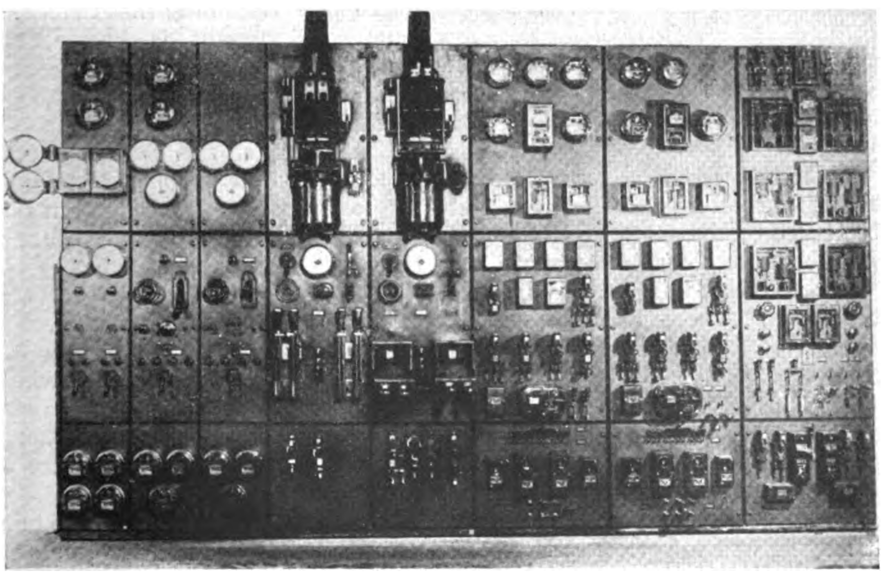
Power Factor—An interesting development is the automatic power factor regulator that has been recently brought out by the Electric Controller & Manufacturing Co. This consists of a contact-making, power factor meter and two relays for controlling a motor-operated or solenoid-operated field rheostat. The principal application for this device will be to maintain approximately constant power factor in a plant. By connecting the instrument somewhere near the center of distribution and adjusting the high and low contacts for the desired range of power factor, the regulator will control the setting of the field rheostat of a large synchronous motor so as to keep the power factor of the system approximately constant.

Ventilation—Ventilation of electrical equipment and of the motor rooms is receiving careful attention on new layouts. With the installation of several large machines in a comparatively small sub-station, as is the case in many of the newer mills requiring large amounts of power, the losses are greater than can be easily dissipated by natural ventilation. Artificial ventilation also is of advantage in keeping the motor room cool. With the motor room under slight pressure, mill dust is largely kept out and the motor room is made cleaner. There is also the possibility of increasing the rating of the machines by artificial ventilation. The water spray or wet washer is still used in some plants for air conditioning, although there is a tendency toward the use of the dry types of filters.

On account of the high flood level of a small stream flowing through the property of the Phoenix Iron Co. it was not practicable to have basements under the motor rooms, in which to place the ventilating equipment. Hence, the air washers and fans were located on the floor of the motor room. All of the air ducts are lined with ¼-in. steel plates and all joints riveted and electrically welded, so as to prevent seepage of water into the ventilating system.

Increasing use is being made of automatic substations in the steel industry.

This Westinghouse automatic equipment controls synchronous motor-generator sets and feeders in a large steel plant in the Pittsburgh district.



* * * *

Illumination—Safety Electric Heat

Illumination—Marked impetus is noted in the recognition of the value of good lighting in mill yards and buildings. More attention is being paid to the specific requirements of different kinds of mills and to the different operations within a given mill. Special pains are being taken to make the lighting units accessible for repair and cleaning.

Floodlighting of yards, docks, and areas in which work is conducted at night, is receiving much more attention than formerly. Also, more efficient and larger lighting units have

(Please turn to page 275)

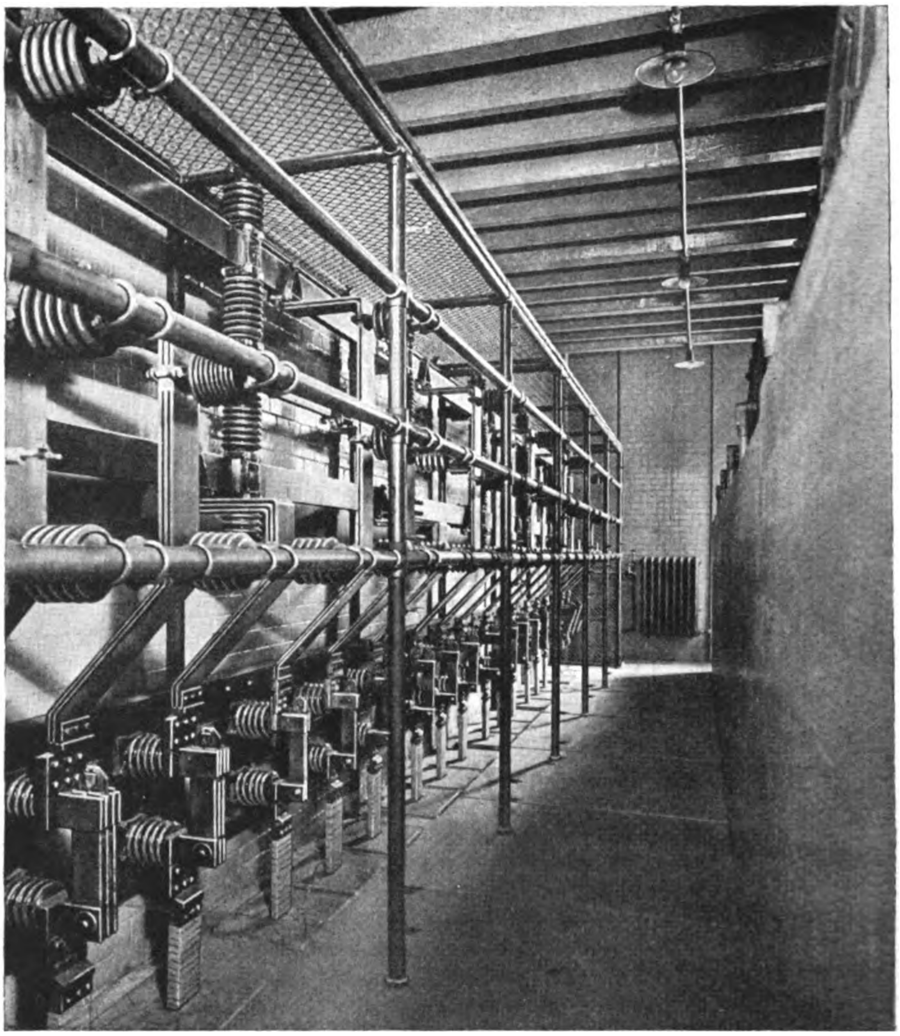


Fig. 1 — This view shows a typical industrial plant installation with standardized unit-type bus supports and disconnecting switches

Considerations that influence

Layout of Heavy Bus Structures

in industrial plants

By W. H. BOYCE
Designing Engineer,
Delta-Star Electric Co.,
Chicago, Ill.

In the design and construction of all bus work there are certain fundamental facts that should be given careful consideration by those who may be called upon to select and install such equipment. It is the purpose of this article to outline some of these facts in a general and practical way, without going too deeply into the mathematics involved.

Practically every bus installation presents problems of its own, in much the same way as the application of any piece of electrical apparatus for industrial use. For example, it is an obvious fact that the straighter a bus can be run, say, from a generator to the switchboard, the more economical it will be in the amount of copper and supports required. However, local conditions may be such that foundations, steam lines, other buses, and so on, may interfere, making straight-line construction impossible.

Many of the details involved in laying out an installation can best be settled by the engineer on the job, who is thoroughly familiar with the local conditions and the problems to be solved. There are, however, a number of features that are common to all installations and may be considered briefly. Before proceeding to outline the various methods employed for mounting the bus work, such as pipe and angle-iron frames, concrete cell structures, and so on, it may be well to review some of the factors governing the selection of the copper. Assuming that the maximum load current is known, the amount of overloads to be taken care of and their duration must be considered next.

Regardless of the voltage of the circuit, the first problem is to keep the heating of the copper within reasonable limits. Generally, the limits taken are those recommended by the former Electric Power Club (now known as Apparatus Division, National Electrical Manufacturers Association) and other bodies, which specify a 30-deg. C. rise over an ambient temperature of 40 deg. C., or a maximum operating temperature of 70 deg. C.

It is good practice to keep the temperature rise below these limits if

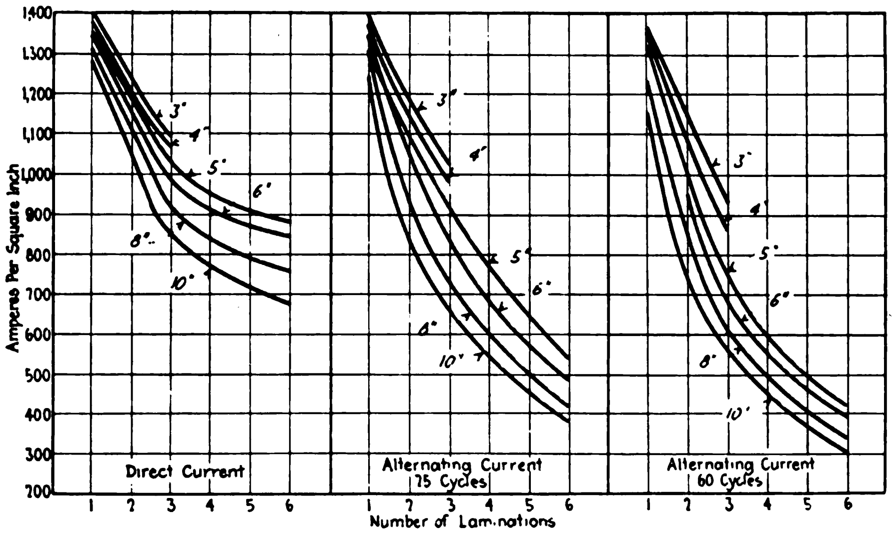


Fig. 2—These curves show the permissible current density in laminated copper busbars.

The busbar in the direct-current section was installed on edge in the open air with ¼-in. spacing between laminations. The curves in the 25- and 60-cycle sections are based on 8-in. spacing between phases and 30 deg. C. temperature rise above 40 deg. C. ambient temperature.

possible, and insofar as buses for direct current service are concerned, this means only providing sufficient copper to take care of this heating. On the other hand, the use of alternating current introduces other factors besides heating that must be taken care of, such as skin effect, mutual inductance between conductors, and so forth, that will be covered later in this article.

Assuming then, for the present, that we are dealing only with direct current, the next question to be answered is whether cables or bars shall be used for the conductors. With the exception of collector rails for cranes and locomotives, and certain classes of high-voltage outdoor construction, copper bars or cables are used almost universally. Aluminum has been used to a limited extent in certain process industries, where the buses would be exposed to the action of corrosive gases. The use of this metal presents certain problems in compensating for its expansion and contraction. Furthermore, aluminum has approximately only 60 per cent of the conductivity of copper. Consequently, at this time we will consider only the use of copper as bus conductors.

Where cables are used for buses they are invariably insulated for, or in excess of, the operating voltage. This is often a decided advantage from the standpoint of safety where there is the possibility of inexperienced workmen coming in contact with them. On the other hand, bare copper bar very often has the advantage of lower installation cost and can be worked at higher current densities on account of the increased radiation. Safe operating conditions can also be obtained in the majority of cases by means of suitable inclosures.

Local conditions will largely influence the selection of the conductor, but in general it may be said that for currents above 2,000 or 3,000 amp., it is advisable to use busbar rather than cable. The methods used for supporting and mounting various sized cables are in general much simpler than those required for busbars; so we will confine ourselves for the present to the latter.

It is standard practice with the majority of engineers to limit the current density in busbars to 1,000 amp. per sq.in., which is the equivalent of one 4 x ¼-in. bar. On this basis the maximum temperature rise for a single bar will be considerably below the 30-deg. limit. Referring to the chart shown in Fig. 2, it will be noted that the permissible density falls off very rapidly as the bars increase in width as well as in number. These curves are based on the performance of ¼-in bars mounted vertically. Where bars are run horizontally instead of vertically, the heating will be increased from 15 to 25 per cent, depending on the number of bars, due to the decreased

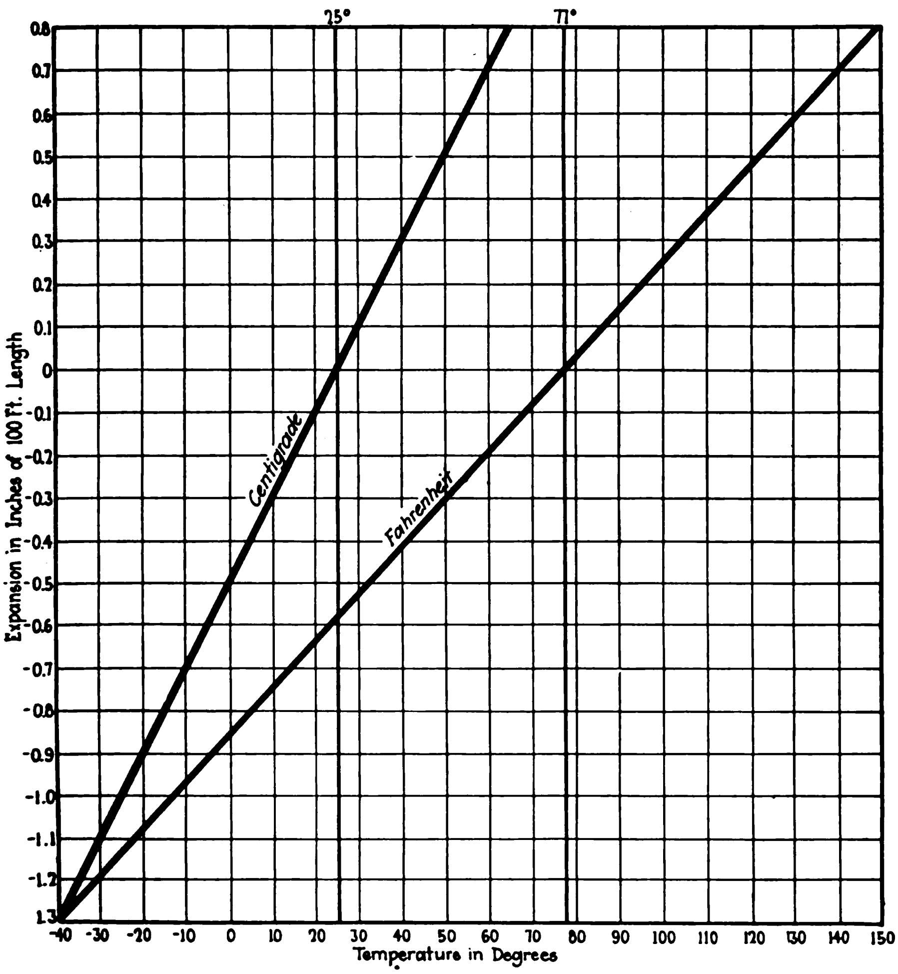


Fig. 3—Linear expansion curves for copper busbars.

For each 100 deg. F. increase or decrease in temperature there is 1 in. of expansion or contraction. This chart is based on the formula $L \times 0.0000092 \times$ deg. F. = expansion in inches.

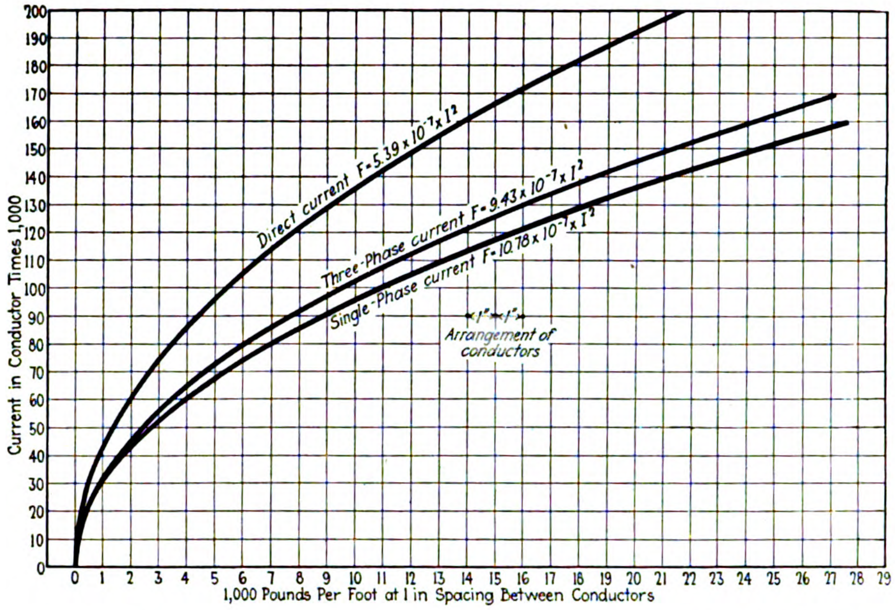


Fig. 4—These curves show the magnitude of the electro-magnetic stresses in busbars at the moment of short-circuit.

ventilation and the mutual heating of adjacent bars.

If the bus run is not very long, no provision need be made to take care of the expansion and contraction of the copper. However, if the temperature variation is very great or the length of the run exceeds 50 or 60 ft., expansion joints or bends in the copper must be provided. The extent of this expansion and contraction with changes in temperature may readily be obtained by referring to the chart shown in Fig. 3, which gives the change in length of copper in inches per 100 ft. based on the formula,

$L \times 0.0000092 \times \text{deg. F.} = E$, where L equals the total length of the bus section in feet and E equals the increase or decrease in inches.

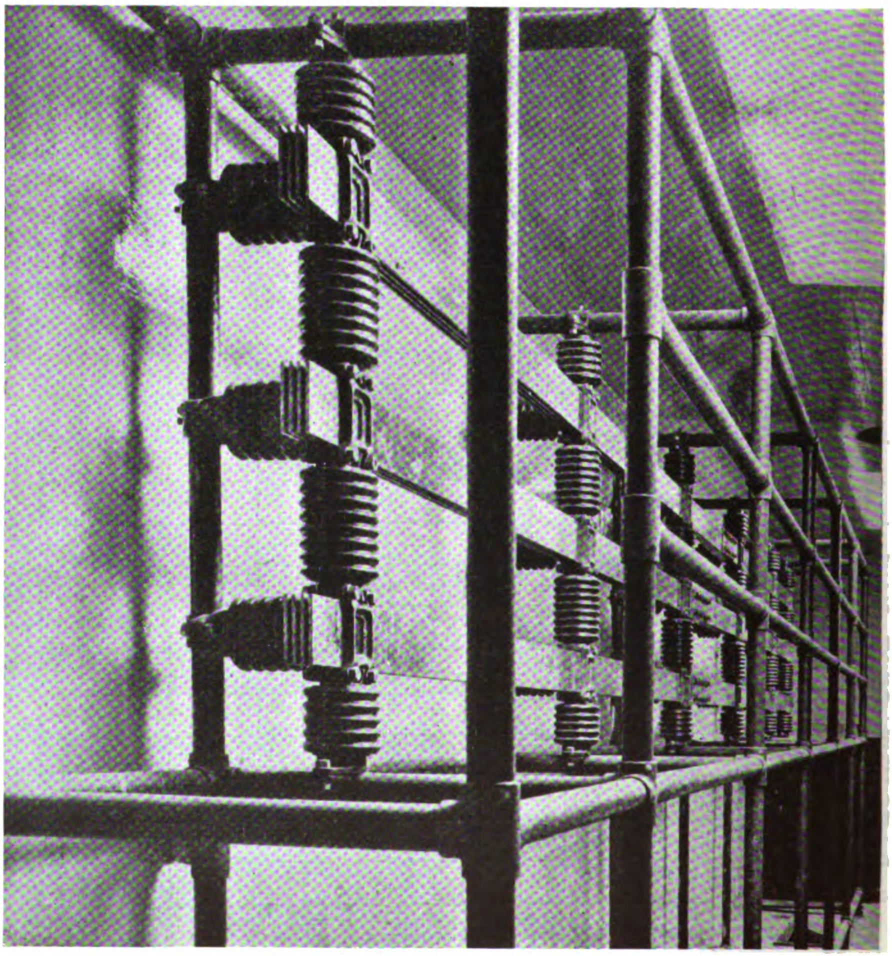
One of the most important considerations in installing buses is the insulation of the bus supports, for regardless of the operating voltage, the material selected should have the following characteristics: It must possess high dielectric strength; it should be non-absorptive, unaffected by ordinary temperature changes and should flash over before puncturing. In addition it should have high mechanical strength.

Wet-process porcelain has all of the above requirements and is used more universally than any other material.

The question of mechanical strength is of far greater importance than may appear at first sight, for not only must the bus support be able to carry the dead-weight load of the busbar, which, in the case of large buses, is considerable, but it must also withstand the enormous mechanical stresses that will be set up between conductors in the event of a short-circuit. Short-circuit currents are limited only by the capacity back of the bus and the amount of reactance in the circuit. Referring to Fig. 4, the curves therein show the relation between the current flow in amperes and the mechanical stress in 1,000 lb. per. ft. with 1-in. spacing between conductors at the moment of short-circuit.

In the average industrial plant it is very seldom that the total reactance in the circuit exceeds 10 per cent. This means for example, that where the maximum capacity is 3,000 amp., a dead short-circuit would mean a momentary current of 30,000 amp. Referring again to Fig. 4, we see that this would develop a force of 500 lb. per ft. Assuming a 5-in. spacing between conductors, this would be equivalent to 100 lb. per ft. and with the supports placed 5 ft. apart, would mean that the equivalent of a 500-lb. blow would have to be withstood momentarily by each support. There is a possibility in large installations of the short-circuit currents reaching a value as high as 75,000 or 100,000 amp.; so under these conditions, it can readily be seen that unless ade-

Fig. 5—In these standardized, unit-type, heavy-duty bus supports the porcelain is under compression.
Porcelain meets all of the requirements for satisfactory bus supports. It has more than enough mechanical strength to withstand the maximum force developed in busbars under short-circuit conditions.



quate provision is made for withstanding these large forces, the bus work will be completely wrecked.

Porcelain insulators of the type supplied by various manufacturers for use as indoor bus supports will have a cantilever strength varying from 500 to 4,000 lb., depending upon the size, voltage, and type. Very often, this is entirely inadequate to resist the disruption forces existing between buses under short-circuit conditions, as previously outlined. And yet these same insulators, when placed in compression, will have a total strength varying from 25,000 to 80,000 lb. This is far greater than the maximum force that would ever be developed under short-circuit conditions. Figs. 5 and 6 illustrate two general methods used in building up combination supports, placing the porcelain insulators under compression.

In connection with buses for alternating-current service there are several additional factors besides the heating effect of the current that have to be taken care of in the design of the bus. Referring back to Fig. 2, it will be noted that the carrying capacity of busbars in amperes per square inch falls off much more rapidly with alternating-current where the width of the bars as well as the number of laminations are increased. This curve can be followed where the maximum, average current does not exceed 2,500 or 3,000 amp., but above this point it becomes necessary to divide the bus into sections to take care of the so-called skin effect, edge effect and proximity effect of adjacent buses. When currents of 2,500 to 4,000 amp. are to be handled it is customary to divide the bus into two sections. This not only compensates for the skin effect of the current, but also gives better radiation due to the separation of the busbars into two groups. This type of construction is illustrated in Fig. 7.

For currents of 4,000 to 7,500 amp., the most economical arrangement of the bus copper can be made by dividing it into four sections, so arranged that the copper will approximate as nearly as possible, the condition that would exist if a tubular conductor were used. Two methods of doing this are shown in Figs. 8 and 9. Above 7,500 amp., it is necessary in most cases to split the entire bus into two or three sections, and by staggering the phases, as shown in Fig. 10, it is possible to neutralize to a great extent the effect of the heavy magnetic fields surrounding each phase.

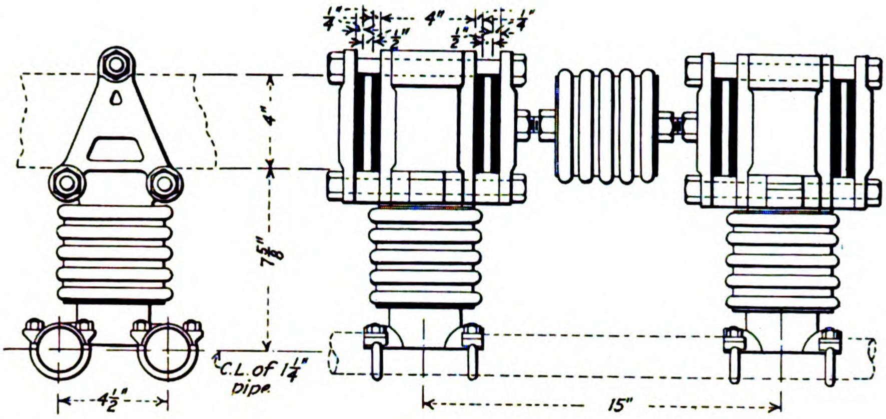


Fig. 7—Special unit-type busbar supports with separators.
The bus is divided into two sections, for handling currents of 2,500 to 4,000 amp.

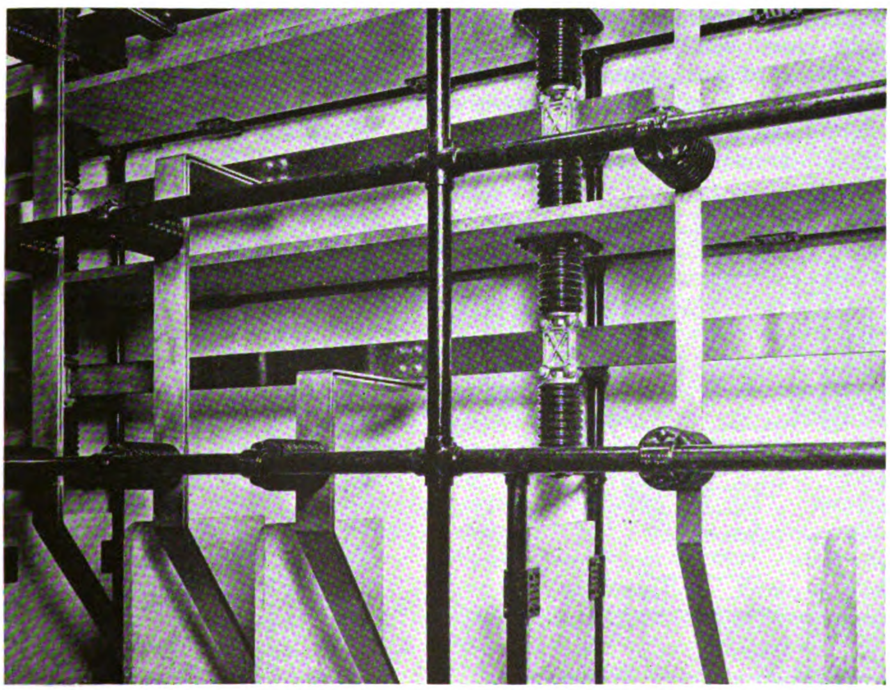


Fig. 6—This shows an installation of heavy-duty, unit-type supports.

Another condition that has to be provided for is the heating effect of eddy currents induced in adjacent iron or steel parts. For this reason it is customary to use some non-ferrous metal in all parts of the supports where the current exceeds 3,000 amp. This includes the hardware on the insulator unit itself, as well as the clamp bolts and nuts for attaching the conductor to the insulators. As the capacity of the bus is increased, it also becomes necessary to keep it a considerable distance away from the supporting steel or the reinforcing bars, if the support is mounted on concrete. In order to do this, it is customary to mount the supports on brass pipes or structural shapes. The distance necessary between the busbars and steel or iron parts will vary approximately from 16 in. to 3 ft. or more, depending upon the amount of current handled.

It is also possible to neutralize the eddy currents generated in the iron and steel supporting members by surrounding them with a copper short-circuiting loop having approximately 25 per cent of the cross-sectional area of the bus. These loops are mounted directly under the bus and act in a way similar to the short-circuited secondary of a transformer.

Where buses are isolated or mounted so that there is a considerable distance between phases, the so-called proximity effect is not a factor that will affect to any great extent the distribution of current in the bars. However, if the dis-

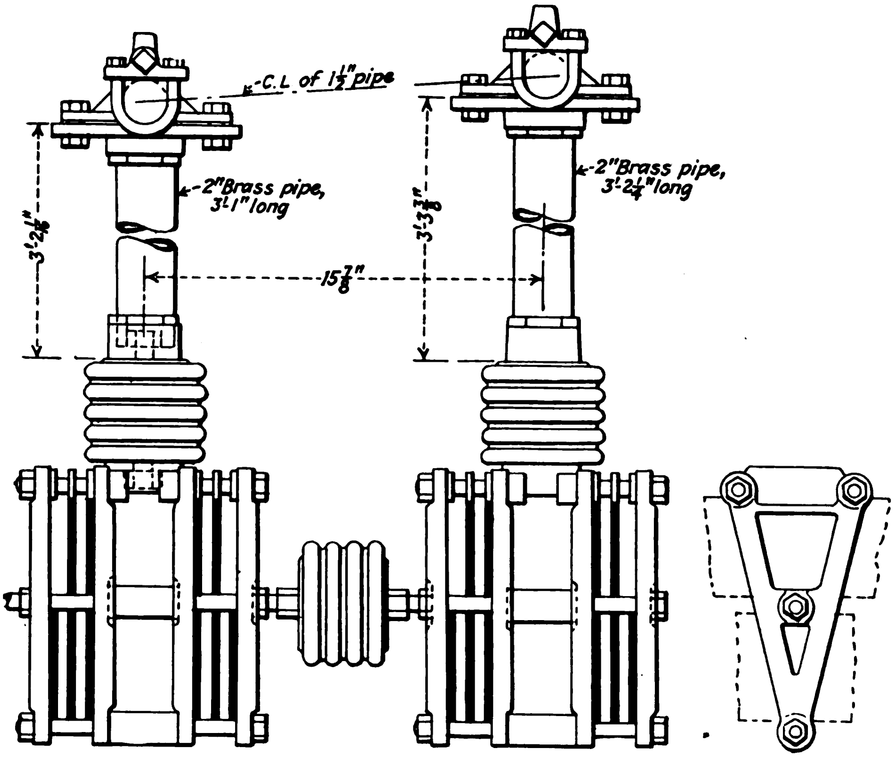


Fig. 8—Here is a four-section bus group with special unit-type busbar supports with separators.

This grouping is recommended when currents of 4,000 to 7,500 amp. are to be carried.

tance between phases becomes too great with a heavy-capacity circuit of considerable length, there will be an inductive drop in the bus. It is, therefore, advisable to keep this distance within 4 or 5 ft., if possible. This is something that will vary with almost every installation, depending upon the maximum current, the operating voltage, and the distance involved.

In a good many cases where it is not practicable to secure wide separation between phases, due to lack of space or other causes, it will be found that the bars of a group that are adjacent to the opposite phase will run considerably hotter than the outer bars of the group. Also, where the bars are placed in the formation shown in Fig. 8, the top bars of the inner group will be somewhat hotter than the lower ones, due to the absorption of heat given off from the lower bars.

If bars are grouped as shown in Fig. 9, the top bars will also have an additional temperature rise, due to decreased ventilation as well as absorption of heat from the inner bars. It has been found as the result of numerous tests, that the additional temperature rise of the inner bars of a group, is due not only to unequal distribution of current in the bus, but also to an inductive effect set up by the field distortion of the adjacent phase or phases.

There are numerous ways of mounting the supports for buses; this is a feature that will vary with each individual location. In the case of isolated-phase construction, they are generally run in concrete-cell structures and when this is done, care must be taken to provide sufficient ventilation so that the heat generated in the buses will be dissipated.

Other means employed consist of structures which may be made of pipe framework or structural steel, although pipe has the advantage, in lighter construction, in that it can be clamped together in almost any shape without the necessity of drilling holes or threading. For heavier buses, where the dead-weight loading is too great for a pipe framework, structural steel consisting of standard shapes may be used. Depending upon local conditions, both the pipe and the structural steel framework may be built up either from the floor or suspended from the steel members of the building framework.

It may be said that, in most cases, greater economies in construction can be effected and better operating conditions secured by keeping the maximum current in buses below 7,500 amp., even though it is necessary to increase the operating voltage in order to do this.

Fig. 9—Special mill-type bus supports with separators.

This arrangement approximates the condition existing when tubular conductors are used.

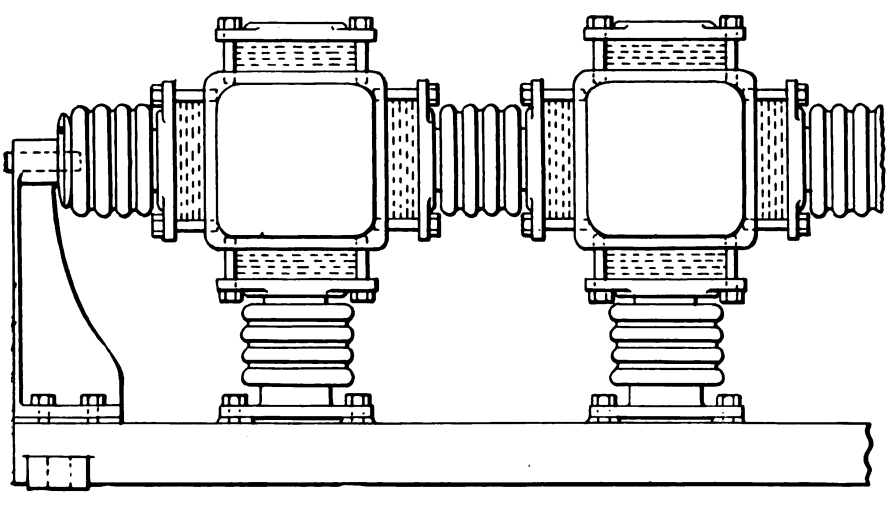
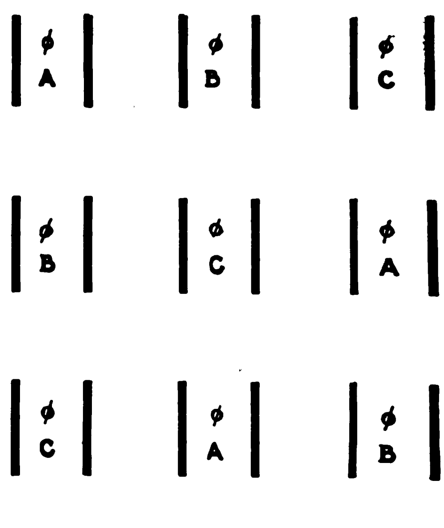


Fig. 10—This shows a three-phase, low-voltage, high-capacity bus assembly plan.

When carrying currents above 7,500 amp. the bus is split into sections with the phases staggered as shown to neutralize the effect of the magnetic fields surrounding each phase.



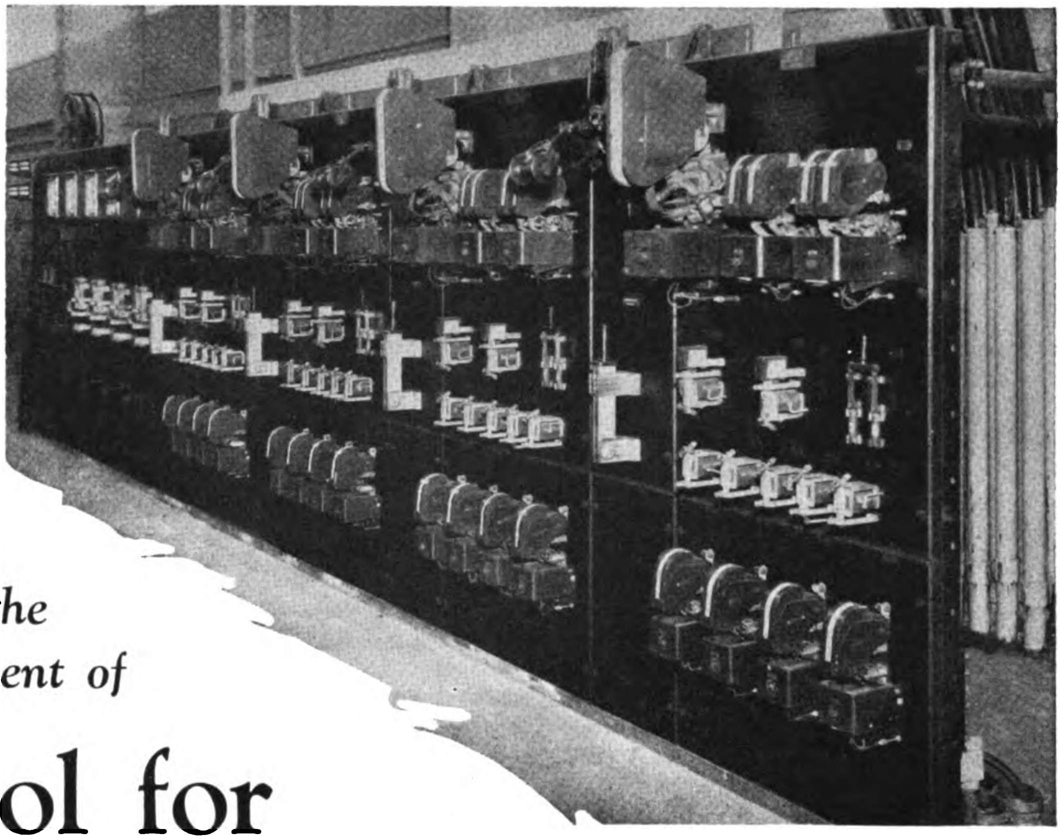


Fig 1—Here are the control panels for four 800-hp. adjustable speed, 600-volt d.c. motors driving the finishing stands of a 12-in. merchant mill in the plant of the Corregan McKinney Steel Co., Cleveland, Ohio.

Steps in the development of

Control for Steel Mill Auxiliaries

By G. E. STACK
Industrial Control Engineering Department, General Electric Co., Schenectady, N. Y.

ONE of the reasons for the wide and extremely successful application of electric motors in the iron and steel industry is to be found in the correspondingly rapid development of suitable control equipment for starting and stopping the motor and, in many instances, regulating its speed. During this period of development there have been many interesting trends and, at times, rather marked differences of opinion and practice.

Looking back, for a moment, the small direct-current motors originally applied on the simpler drives required only a simple form of control for starting and stopping. Either a faceplate dial starter, or the stronger drum switch, sufficed.

The success that attended the first motor applications created a demand for more motors, as well as for motors of larger capacity. The larger motors required control for handling heavier currents. The dial starters were consequently provided with a contactor having a magnetic blowout for making and breaking the motor armature circuit, the dial part being used only to cut the starting resistor in and out of the armature circuit.

The drum switches were also made for greater current capacities and the fingers were provided with magnetic blowouts. These control devices soon became too large and cumbersome, however, for manual operation, especially on drives that required frequent starting and stopping.

The development of magnetic contactors progressed rapidly under these conditions. They were applied first for handling large currents and were well suited for this service. A drum switch having a number of contacts, each designed to handle from 300 to 500 amp. or more, was too large to be operated conveniently by hand, but a small master drum switch sufficiently large to handle the coil circuits of the magnetic contactors, together with a sufficient number of contactors, made a controller combination that was easy to manipulate. These magnetic control equipments could be maintained at a lower cost than any other type of control, and partly for this reason they were gradually applied to smaller motors.

By providing interlocks (auxiliary contacts sometimes called butterflies) on the contactors and wiring the succeeding contactor coil circuit through them, a definite sequence of closing was established. Then, by adding suitable current relays, the successive closing of the contactors could be stopped when the motor current exceeded a predetermined value. This combination of contactors and relays proved very satisfactory as it provided protection for the motor during starting, and became known as current-limit control.

Overload relays provided with suitable, adjustable means for opening the line contactor coil circuits protected the motor from running overloaded. By the use of suitable interlocks undervoltage protection was provided, and thus the motor was prevented from starting up after a voltage failure, until the operator intentionally manipulated the master drum switch or pushbutton.

Magnetic control provides so many protective features for the motor, the driven machine, and the operator, that its use has in the past few years become general, not only on large and small motors in steel mills but in all other manufacturing plants as well. The hand control devices now used are few and relatively simple; therefore this article will deal largely with magnetic control.

Control for D. C. Motors Driving Steel Mill Auxiliaries

Under the classification of auxiliaries are included screwdowns, manipulating fingers and bars, roll tables and other drives requiring frequent starting, stopping and reversing. Series motors or motors with strong series characteristics are generally used and only magnetic control with powerful blowout coils on the contactors will stand up successfully for long periods. The master switches for operating the panels are made small and strong so that one man can operate several without becoming fatigued. Some of the earlier panels consisted of four reversing contactors and a suitable number, four or five, resistor or accelerating contactors. The closing of the contactors was governed by two separately-mounted, current-limit relays that operated alternately.

Later and less complex forms, instead of having separately-mounted relays, had one individual current-limit relay or interlock provided with a series coil for each of the accelerating contactors.

One form of this relay was designed with a small range between the pick-up and drop-out current values. As the relay was wired in series with the main circuit of a contactor, it would open its contacts on the inrush caused by an accelerating contactor closing and cutting out a section of the resistor. The contacts were held open until the motor current dropped to the predetermined value and were then closed, thus energizing the next accelerating contactor.

Another form of this relay, shown in Fig. 2, was mounted directly on the contactors and was called a current-limit interlock. These interlocks were made with both series and shunt coils. Those with shunt coils were usually mounted on the line or reversing contactors, with the shunt coil so connected that it would be energized from the voltage drop across the starting resistor.

The interlocks with series coils were connected so that the motor current flowed through the entire coil until the closing of the contactor on which the particular interlock was mounted. When the contactor closed, the current passed through only a part of the coil, and at the same time the mechanical support of the plunger was removed so that it was supported only magnetically and was free to fall as soon as the current flowing through the half coil decreased to the predetermined value. The plunger carried a contact disk which completed the circuit to the coil of the next accelerating contactor; thus the current was limited to a predetermined value, as each succeeding contactor closed.

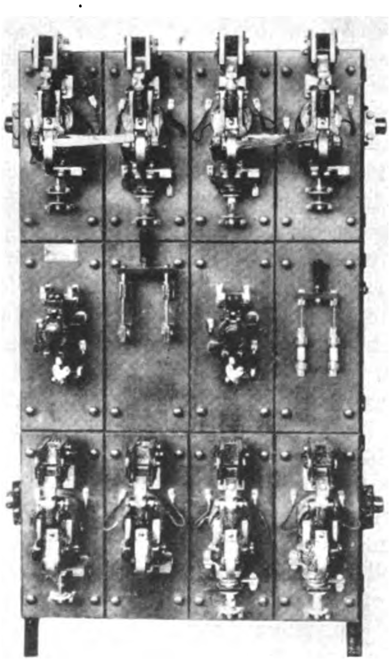


Fig. 2—This control uses current-limit interlocks on the contactors.

The principle of operation is explained on this page. In the unit shown here the forward and reverse line contactors are mounted on the top panels. The line switch, control circuit switch and overload relays are on the center panels. The accelerating contactors and circuit breaker contactor are mounted on the bottom panels.

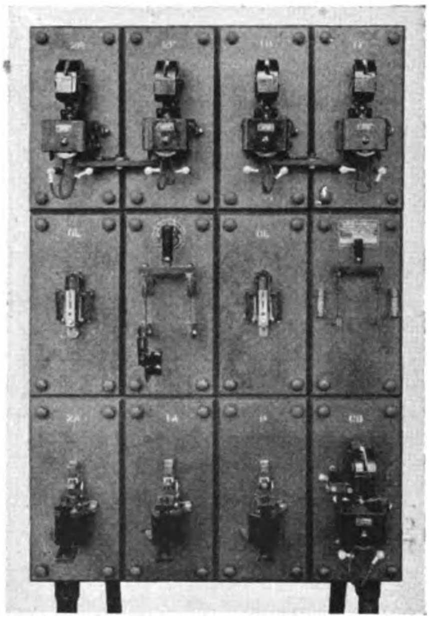


Fig. 3—Series lockout contactors are used on this control, which was designed for a 230-hp., 230-volt, direct-current motor.

The forward and reverse line contactors are carried on the top panels. From left to right on the bottom panels are the accelerating contactors, and the plugging and circuit breaker contactors.

Principles of Series Contactor Equipments

Current-limit interlocks were standard for a number of years and several hundreds are still in operation in steel mills throughout the country. About 16 years ago equipments using series lockout contactors (more briefly called series contactors), shown in Fig. 3, made their appearance. These contactors were made in various forms using slightly different principles for their operation. Each, however, had the characteristic of locking open when a current above a predetermined value was suddenly passed through the series coil, and remaining open until the current decreased to the calibrated value; then it would close and cut out a part of the starting resistor.

It would remain closed and keep the resistor shorted as long as the motor current did not drop below 10 per cent of full-load value. In case it *did* drop out a current somewhat in excess of one-third of the full-load motor current was required to close it. This feature, however, did not prove disadvantageous for steel mill applications, because the running current of the series motors seldom decreased below the drop-out value of the contactors.

When these contactors were used on shunt motors or motors with shunt characteristics, an additional coil was added which held the contactor closed as long as the line contactors were energized. These series-contactor control equipments became very popular, especially for steel mill auxiliary drives requiring only straight starting, stopping and reversing, because the wiring of the panel was so very simple. They did not, however, work out very satisfactorily where speed control was required.

These applications of pure current-

limit control naturally suggested possible refinements; consequently designing engineers felt it was desirable to inject a time interval into the control. The principal objection to current limit was that a different adjustment of current value was advisable for a cold mill, as compared to a warmed-up mill. This quite frequently necessitated changing the current-limit setting every time the mill started up after a long shutdown. It at least required that the contactors be pushed in by hand until the mill loosened up. In the case of a new mill, continual readjustments were necessary until the mill was worn in. When applied to drives with variable load and with the relay adjusted to accelerate the maximum load, the light load would be rushed up to speed, putting the same stresses on the gears and driving machinery as when starting the heavy load.

Again, the progress in motor design had at this time advanced to the point where the motor would stand occasional high peak overloads, which was another argument in favor of time-limit control.

Control using dashpots was tried out for steel mill operation, but all the disadvantages of the dashpot were emphasized. Therefore, the voltage-drop system was developed to meet the conditions imposed.

One form of the voltage-drop system consists of a current-limit action in combination with a time lag, a separate relay being used for each accelerating point. This combination is shown in Fig. 4. The relays have normally closed contacts and are provided with two shunt coils. On starting, the pick-up coils of each relay are first energized simultaneously, thus opening the contacts of all the relays. At the same instant the holding or calibrating coils are shunted across various parts of the starting resistor, thus subjecting them to the drop in voltage across this resistor. As each contactor closes in succession, it short circuits the operating coil of the relay controlling that contactor, and also short circuits the resistor coil of the next relay, leaving it free to function when the line current again decreases to the value corresponding to the desired setting. The time lag is caused by the assistor coil being short-circuited and not open-circuited. Thus a definite time is required for the operation of the relay because of this, even though the voltage on the operating coil falls rapidly to less than the calibration values.

This system, from the engineering standpoint, is nearly ideal for any control involving current limit. It is, however, somewhat more complicated than a straight time-limit system, a form of control that has met with great favor among steel mill electrical engineers.

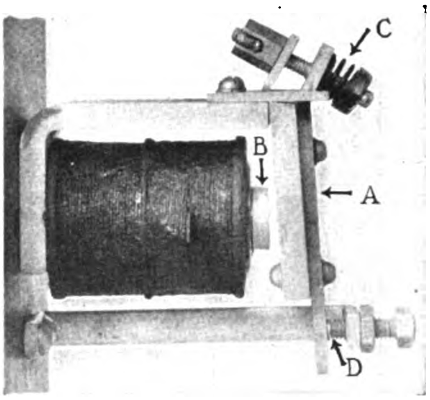
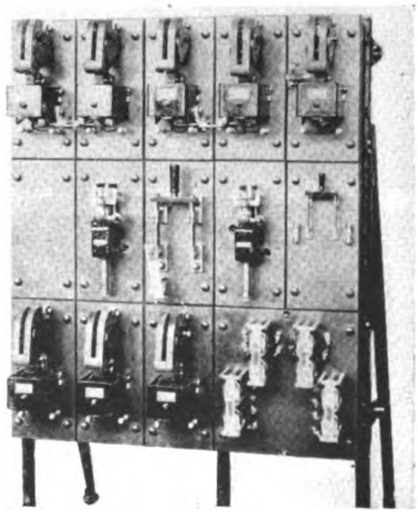


Fig. 5—Here is a magnetic time-limit relay.

When the coil is energized the armature, *A*, is attracted towards the pole, *B*, against the force of the calibrating spring, *C*. This closes the magnetic circuit and opens the contact at *D* in the coil circuit of the accelerating contactor. When the relay coil is de-energized by being short-circuited the armature is free to drop out and close the contact again. However, due to the self-inductance of the short-circuited coil in connection with the heavy magnetic circuit, there is a time delay that holds the armature in and the contacts open for 0.4-1 sec., depending on the setting of the calibrating spring. Adjustment of the time element can be obtained by inserting brass shims between the armature and pole.

Fig. 4—This shows a control that uses the voltage drop principle.

The forward and reverse line contactors are at the top of the board. The lower panels carry the accelerating contactors, at the left, and the accelerating relays. The principle of operation of this type of control is explained in the left-hand column.



Magnetic time limit control has attracted considerable attention as it provides definite time-limit acceleration. A very important feature is the simplicity, both of the operating principle and of the various units that make up a complete control equipment. The whole operation hinges upon the principle of magnetic time-delay, a feature present in the previously mentioned form of voltage-drop control. No complicated system of interlocks or other devices requiring delicate and continual adjustments is necessary to give the requisite timing of the accelerating contactors. As a result, the system is highly reliable in its action over long periods of usage. The individual devices that are combined to make up a complete panel are also of the simplest character.

A vital principle of the magnetic time-limit system rests in the method whereby the proper timing of the accelerating contactors is obtained by means of definite time relays. These relays are of the normally closed type and consist of a coil surrounded by an especially heavy magnetic circuit operated practically at the saturation point. As the effectiveness of the control as a unit depends upon the action of these relays, a description of their construction and operation is given in the caption accompanying Fig. 5.

There are two particular features characterizing the relays that add considerably to the effectiveness and reliability of the control system of which they are a part. The adjustment is practically constant under all conditions and is unaffected by voltage variations, temperature changes, dust, moisture, or gases. Furthermore, the construction and design of the relays themselves are such that the coils of all relays for a given voltage are identical, regardless of the horsepower of the motor to be controlled. As a result, they are interchangeable, which reduces the stock of spare coils to a minimum.

A clear conception of the operation of these relays under actual service conditions can best be given by a description and explanation of some specific types of control equipments of which they form a part.

The operation of the reversing control, a simplified wiring diagram of which is shown in Fig. 6, is substantially as follows: First, assume that the motor is to be started from rest, in the forward direction, and that the line switch has been closed.

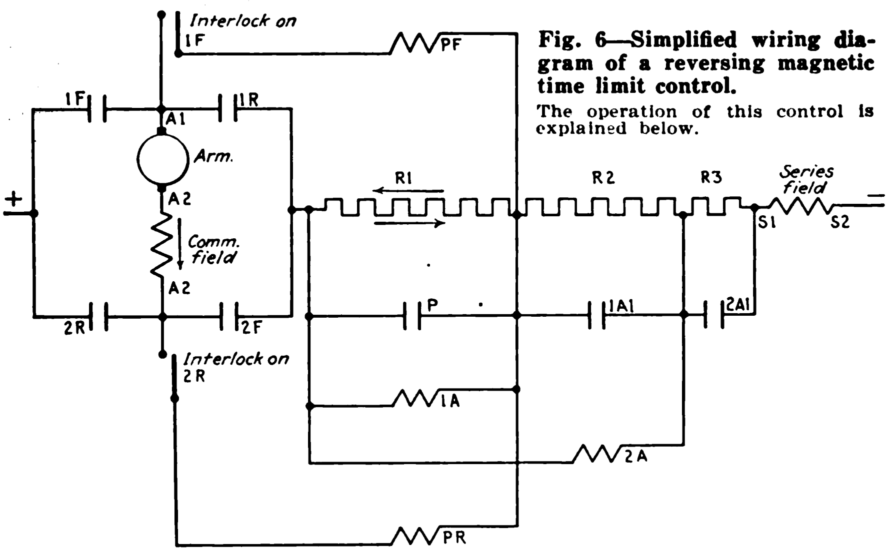


Fig. 6—Simplified wiring diagram of a reversing magnetic time limit control.

The operation of this control is explained below.

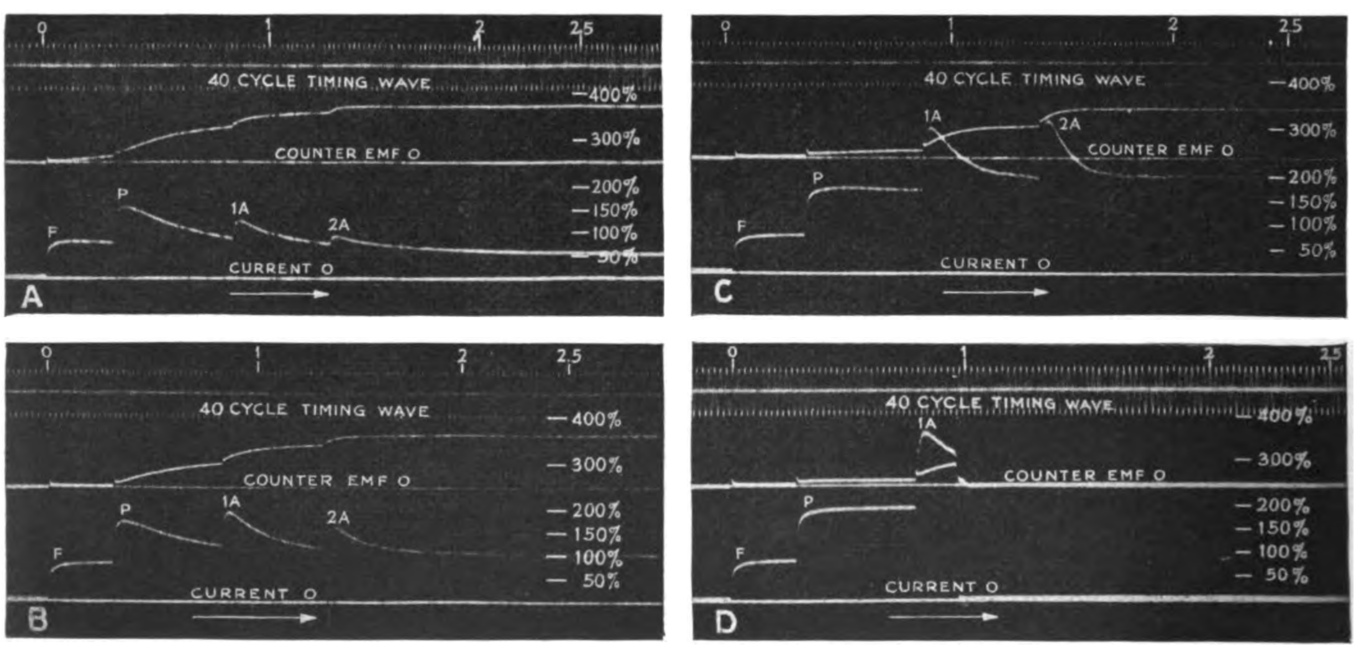
When the master switch is moved from the off position to the forward position, the contactors *1F* and *2F* close, allowing current to flow through the motor and the starting resistors *R1*, *R2*, and *R3*. At this point two operations take place simultaneously: a voltage equal to the *IR* drop across resistors *R1* and *R2* is impressed on the coils of accelerating relays *1A* and *2A* which immediately open their contacts, and an interlock on contactor *1F* closes the coil circuit of the counter-emf. relay *PF*. As the *IR* drop across resistor *R1* and either the *IR* drop or the counter-emf. in the motor armature are in the same direction, the sum of the former and either one of the two latter is enough to energize the relay coil, causing it to pick up its armature and close its contacts. Only a small percentage of the relay closing voltage is enough to hold its contacts closed; so either the *IR* drop across the motor armature or the increasing counter-emf. will hold it closed after resistance *R1* has been shorted out.

Closing of the relay contacts completes the coil circuit of the plugging contactor *P*, which closes, short-circuiting resistor *R1* and the coil of the accelerating relay *1A*. After a definite time delay the armature of this relay lets go, and closes its contacts, completing the circuit of the actuating coil of the accelerating contactor *1A1* which closes, cutting out resistance *R2*. Closing of the contactor *1A1* short-circuits the coil of accelerating relay *2A1* which, after a definite time, releases its armature, thus closing accelerating contactor *2A1* and cutting out the last of the resistance in the motor armature.

The action of the control when the motor is reversed, or plugged, while practically the same so far as the physical sequence is concerned, involves some difference in the electrical phenomena which bring about this sequence. When the master controller is moved to the off position, the accelerating, plugging and forward contactors will open, disconnecting the motor from the line. When the switch is moved to the reverse position, contactors *1R* and *2R* will close, admitting current to the motor in the reverse direction. Relays *1A* and *2A* are energized and open their contacts. An interlock on *2R* closes the coil circuit of the counter-emf. relay *PR*, but since, at the instant of closing, the counter-emf. of the motor is in the opposite direction to the *IR* drop across the resistor, the two tend to neutralize each other, and relay *PR* will not

Fig. 7—These oscillograms show the conditions existing during acceleration of a motor with magnetic time limit control.

The upper curve is a 40-cycle timing wave calibrated in seconds for convenience in determining the time consumed in the operation of the equipment. The middle curve represents the counter-emf. of the motor armature and the bottom curve, the armature current. The figures at the right indicate the percentage of full-load current. The peaks marked *F*, *P*, *1A*, and *2A*, show the point of operation of the forward and plugging contactors and the two accelerating contactors, respectively. Acceleration under light load is shown in oscillogram *A*. The total time from rest to full speed is about 1.3 sec. Acceleration under 100 per cent load is shown in *B*, where the time required to attain full speed is about 1.4 sec. In *C*, acceleration under 100 per cent overload is shown. Full speed is reached in about 1.8 sec., and the current peaks bear about the same relation to the load as in oscillogram *B*. Acceleration of a stalled motor is shown in *D*. The overload relay opened the circuit before contactor *2A* closed.



close its contacts. As the speed of the motor decreases, its counter-emf. decreases and the voltage impressed on the coil of relay *PR* gradually increases until, at about the instant when the motor armature comes to rest, this relay closes its contacts, energizing the coil of the plugging contactor, *P*, which closes, cutting out resistor *R1* and short-circuiting the coil of relay *1A*. The remainder of the sequence is similar to that described in the case of starting from rest.

An analysis of this operation shows that, although the motor is thoroughly safeguarded during starting from rest or in plugging, no element is present that will unnecessarily limit the speed with which it responds to the movement of the controller. As far as the control itself is concerned, the two operations are absolutely independent. For example, on starting from rest the plugging resistance is cut out of the circuit immediately, whereas in plugging, it is kept in until the motor has come to rest, limiting the current during plugging to a safe value.

These points are brought out in the accompanying oscillograms, Figs. 7 and 8. As the oscillograms in Figs. 7 and 8 represent varying phases of two distinctly different operations of the control, they will be discussed separately. All of these records were, however, obtained on the same equipment and without any alteration in the adjustments of the control apparatus.

In the first group, Figs. 7*A*, *B* and *C* which covers acceleration from rest under varying load conditions, it will be noted that, in spite of the increase in load, the total time from zero to full speed does not increase in anything like proportion to the load, and that the speed of the motor, as indicated by the counter-emf. curve, shows a smooth and rapid acceleration under all conditions. Furthermore, as the plugging contactor, designated as *P* operates about 0.3 sec., after contactor *F* to short out the plugging resistance, no delay is caused in the acceleration. It will also be noted that, although the current peaks are naturally higher for normal, Fig. 7*B*, and 100 per cent overload, Fig. 7*C*, they are never excessive and in every case bear about the same relation to the load.

Fig. 7*D* represents an attempt to accelerate a stalled motor from rest. It will be noted that the overload relay operated so rapidly that the motor was cut out of the circuit even before the second accelerating contactor could close.

In the case of the second group, Figs. 8*A*, *B* and *C*, which covers plugging reverse under the same conditions, the records show that although the time taken for the motor to come to rest from the forward direction varies with the load, the plugging contactor *P* never closes before the motor speed reaches practically zero. In other words the protection provided by the plugging resistor is not removed until the need for it has ceased. At the same time no delay is caused by leaving the resistance in the circuits longer than necessary.

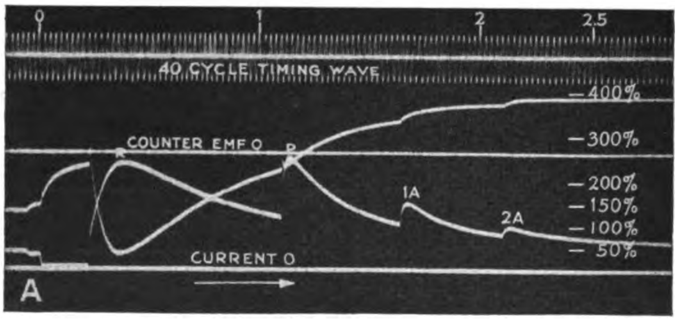
In inductive time limit control a transformer arrangement is used for inducing a flow of current in lockout coils. In addition to the usual shunt closing coil, each accelerating contactor is provided with a second shunt lockout coil that acts on the tail piece of the armature. The air gap of the magnetic circuit for this lockout coil is adjustable by means of shims underneath the coil and by an air gap adjustment which, when once determined, can be definitely set. The solid core transformer on the rear of the control panel is equipped with shunt coils. The number of coils on the transformer is one more than the number of accelerating contactors. The mutual inductance between the coils on this transformer is utilized to provide currents that control the holding-out period of the accelerating contactors.

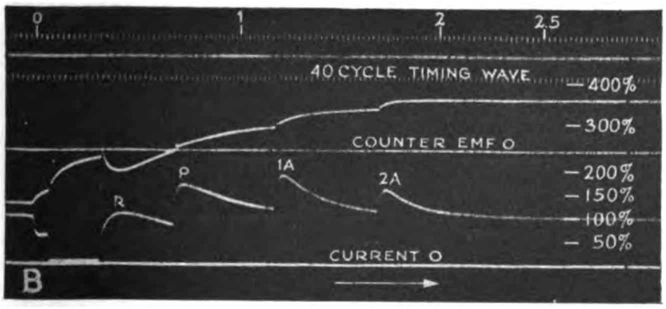
As the holding-out coil on each accelerating contactor is connected to its respective transformer coil, and is of relatively low resistance, these coils act as a low-resistance load, each connected to its own transformer winding. The transformer windings are mounted on a common core, so that they all bear a definite relation to each other. Any reversal of or change in the transformer flux will cause an induced current in the short-circuited transformer coil. This sets up an electromotive force that at first tends to oppose the building up of the flux and, after the change in flux has ceased, causes a current to flow between the holding-out coil on the contactor and the transformer coil. This current is of a transient nature and tends to maintain the change of flux.

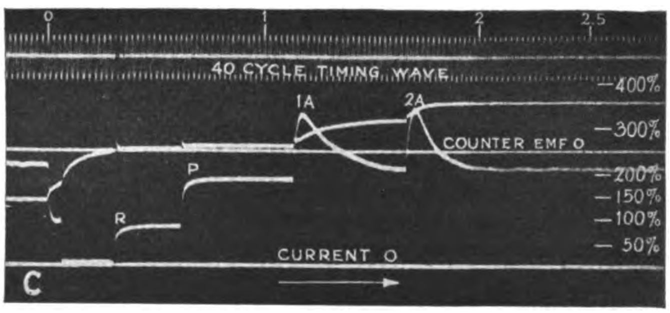
The diagram in Fig. 9 shows, in simplified form, the relation of the

Fig. 8—Conditions under plugging reversing of motor with magnetic time limit control.

The curves and markings at current peaks are the same as explained for Fig. 7. Plugging at light load is shown at *A*, which indicates that the time from full speed forward to full speed reverse is about 2.25 sec. In *B* it is seen that under 100 per cent load the time between full speed forward and full speed reverse is about 1.9 sec. When plugged at 100 per cent overload, *C*, the time is about 1.95 sec.







transformer coils to one another, and their connections to the holding-out coil on the accelerating contacts.

Transformer coil *1* controls the plugging switch. It is so connected that in starting from rest the plugging switch has practically no time lag, but, in plugging, the closing of the plugging contactor is delayed until the motor has come to rest and is ready to reverse. Transformer coils *3*, *4* and *5* are each connected across steps of the accelerating resistor and so have a definite voltage drop across them when the motor circuit is first closed. Coils *3* and *5* are accumulative and coil *4* is bucking.

In starting from rest a very low voltage is impressed on transformer coil *1* and it, therefore, has no effect. Coil *2* is simply short-circuited on the lockout coil of the first accelerating contactor. Because of the magnetic flux set up in the transformer core by coils *3* and *5* overcoming the bucking effect of transformer coil *4*, a current is set up in coil *2*, which holds out the first accelerating contactor. This holding-out period depends upon the design of the transformer and lockout coils, and the adjustment of the air gap on the contactor varies the closing current on the switch and provides the necessary accelerating regulation. When this first accelerating contactor closes, transformer coil *3* is short-circuited, causing a change in flux in the transformer core. This sets up a transient current in coil *3*, which controls the holding-out period on the second accelerating contactor, *3R*, in exactly the same manner as for the first accelerating contactor. The commutation of the successive resistance steps and the changes in transformer flux control the remaining accelerating contactors in the same manner.

From the foregoing it will be seen that the steps in the evolution of control for steel mill auxiliaries have been, (1), manual operation in three forms: dial switches, drum switches and magnetic switches with a master drum. (2), Magnetic control employing automatic current limit. (3), Magnetic current limit with time-delay feature. (4), Magnetic time limit with current limit only on the plugging point.

It is difficult to predict the next step, but it seems likely that it may be straight time delay, or some still simpler method of obtaining this effect.

Control for electric cranes has followed the same general trends as the control for steel mill auxiliaries. To the casual observer this may not appear true, because there are so many cranes in service that are fitted with drum switches and Dinkey controllers for handling the motor current direct.

The crane builders have made a practice of manufacturing and installing cranes complete, including the electrical equipment. In order to quote a competitive price, some of them unfortunately have included the least expensive form of control. The ultimate customer whose buying is governed by price considerations may receive a crane fitted with either drum switches or Dinkey controllers, unless he specifies that magnetic control is desired. The drum switches supplied are carefully designed and provide all the operating characteristics for lowering and hoisting at the various speeds in a satisfactory manner, but the life of a drum switch is very short compared with the life of magnetic equipment. Some engineers have reported, on the basis of very carefully kept records, that it costs in some cases as much as twenty times as much to maintain a drum switch, as it does to maintain a magnetic panel.

The magnetic time control as applied to cranes has proved superior to the current-limit type, especially on such applications as ladle and charging cranes, where it has been the rule to supply current-limit control. Definite time acceleration of moving parts subjected to extreme load conditions, such as crane hooks, permits the operator to judge the travel of the motion better and more accurately.

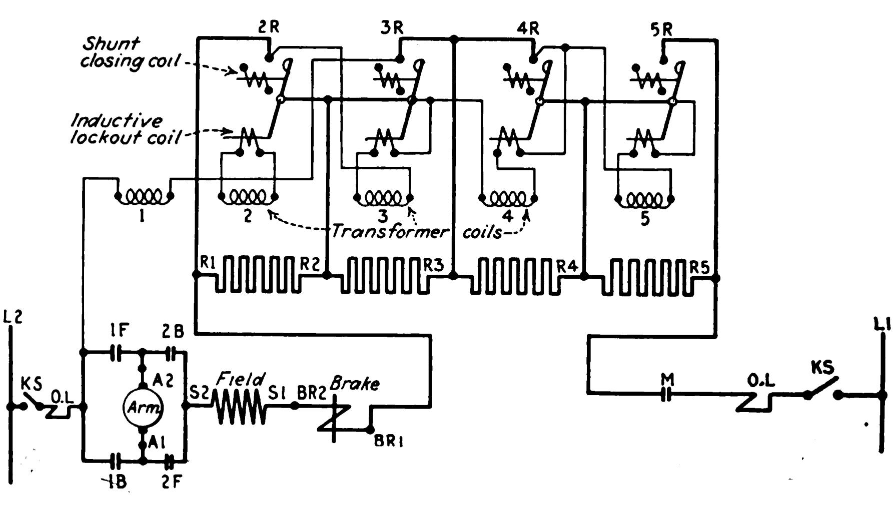
The application of a.c. motors to steel mill auxiliaries has never been on such a large scale as in the case of d.c. motors. Therefore, the demand for control has not been large and as it did not receive as much attention, very few advances have been made. The same type of control used on the main mill drives has been applied to auxiliary drives.

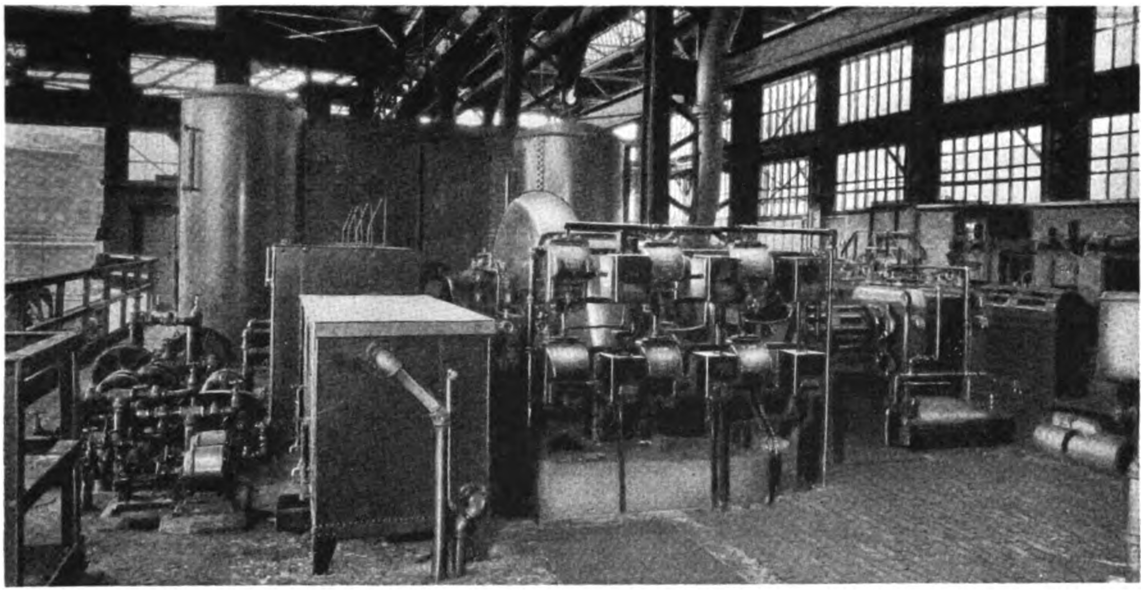
One form of automatic magnetic panel consisted of double- or triple-pole contactors controlled by a pair of current-limit relays, the relays alternately governing the closing of the accelerating contactors. Each contactor had a three-circuit auxiliary interlock that automatically transferred the contactor coil circuits to the proper relay. One relay governed contactors *1*, *3*, *5*, etc., and the other relay governed contactors *2*, *4*, *6*, etc.

Another form of magnetic panel had current interlocks attached directly to the accelerating contactors. These interlocks were operated from the secondary current of the motor and were designed to function on a certain value of current, regardless of frequency. This was necessary because the frequency of the rotor circuit varies from line frequency to nearly zero.

The success attained by the time-limit, d.c. control is having its effect on alternating current to the extent that a few equipments having a time-limit interlock for each accelerating contactor are now being installed. The interlock consists of a simple set of gears, an electrical contact and a pendulum and clockwork escapement. The closing of the contactor compresses a spring that forces the interlock contacts to close. The time element before closing depends upon the length of the pendulum and the amount of travel permitted on the rack.

Fig. 9—Schematic connection diagram of inductive time limit control.





This is an oil circulating and filtering system in a steel mill. The tank in the left foreground is the filter for oil from the bearings; the tank behind it is for oil circulated through the gears. The large round tanks are for oil storage. The circulating pumps for this Bowser system are at the left.

Reclamation of Lubricating and Insulating Oils

By FRANK E. GOODING

Associate Editor, Industrial Engineer

MANY industrial operating men look upon oil purifying or reconditioning devices as being primarily a means of conserving oil. The economy of such apparatus, however, depends not so much on the actual saving of oil as upon the protection given to the units served. In cases where the equipment is wrecked or seriously damaged because of faulty lubrication it cannot be put back into service with the money saved during many years of false economy in the use of lubricants. Again, when a transformer burns out, the money lost would pay for filling it a good many times with new oil.

Problems in oil reclamation, purification, or reconditioning are becoming of increasing importance in industrial plants. Until within the past few years, most of this work has been directed toward the treatment of lubricating oils, particularly from engines.

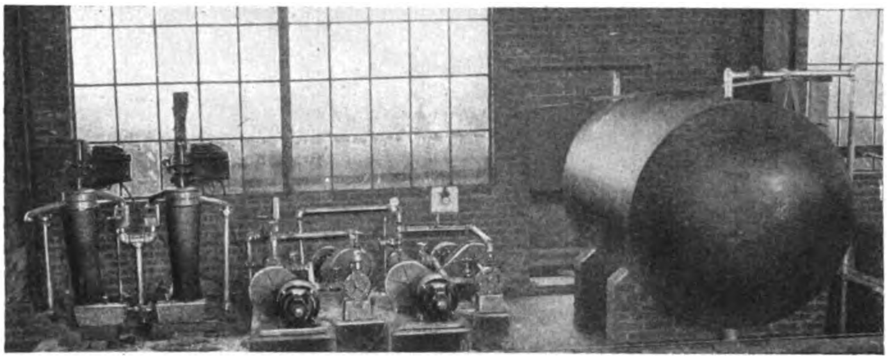
Within recent years the use and re-use of both lubricating, transformer and switch oils has increased until it has become an important consideration in connection with industrial plants containing units of large size or a number of units which would give a sufficient quantity of oil to be worth while saving and treating. In addition, many concerns have adopted a policy of treating all new oil before it is placed in storage to be sure that it is free from water, and rust or dirt that may have become loosened from the inside of the container. In this article some of the problems involved in such treatment and the equipment used, will be discussed.

Contamination of lubricating oil is due to dust from the atmosphere or created in the process, to metallic particles worn from the bearings, gear teeth, or other sliding or rolling surfaces in contact, to foreign particles such as sand or scale loosened from the inside of the gear case, or oil reservoir, and to water which may come from either the atmosphere or be formed in the process.

The method of reclamation or reconditioning must be such that the impurities are removed without affecting the composition of the oil. There are a number of methods of doing this and a wide variety of types of equipment used. In general, lubricating oils may be reclaimed or reconditioned by any one of three common methods, or by a combination of these methods. These methods involve: precipitation and filtration, separation of impurities by centrifugal force, and removal of impurities by coagulating them by the use of special chemicals.

The reconditioning of lubricating oils by precipitation is based on the difference in the specific gravities of oil, water, and the solid impurities. Oil will float on water and if the oil is passed through the water a certain amount of the solids will separate and settle to the bottom of the tank or vessel used. However, precipitation would ordinarily require too much time; also, the oil passes through the water in the form of drops or globules, each of which might contain some of the foreign particles that have a specific gravity very close to that of the oil.

Natural precipitation, which would result from leaving the lubricant



Centrifugal oil purifiers at the Lukens Steel Co.

These two No. 6 Sharples centrifugal oil purifiers continuously recondition and purify the 2,500 gal. of extra-heavy lubricating oil circulated to bearings, pinions, and so on, at the rate of 30 gal. per min. This amount of oil supplies an 84-in. tandem plate mill and a 3,000-hp. G.E. motor-generator set, together with one 2,500-hp. and one 1,200-hp. G.E. driving motor.

stand for a time, would be very slow, especially with oils of heavy viscosity. For this reason, viscosity is frequently reduced by heating the oil, but care must be taken to see that it is not continually agitated which will prevent the natural precipitation of foreign particles.

Some method of filtering out foreign particles, which do not settle readily, is generally used in connection with precipitation equipment. The precipitation chamber is relied upon only to remove the heavier impurities. Filters, in general, are of two types: those containing screens which may be removed and cleaned, and those in which a loose or porous filtering material, such as waste, bone black, Fuller's earth, or other similar materials is used.

The following description of a Nugent filter of the cabinet type, shown in an accompanying illustration, indicates the operation as well as the general construction of one of these units. This is a triple-bag, cabinet-type unit and is designed to separate all foreign matter, including water, from the oil. The top part of the cabinet is divided into three sections; the first section is the dumping tray. The oil then passes through 2 in. of washable filtering material that removes most of the heavy foreign matter but not the water.

The oil then flows into the second or precipitating chamber where the water settles to the bottom and is drawn out. The oil, now free from water, overflows through a pipe into the filtering bags which occupy the third and lowest chamber and extend into the storage reservoir below. Three thicknesses of filtering cloth remove the dust and fine dirt and the oil then passes into the storage chamber, from which it is drawn as used.

Provision is made in this unit for heating the oil in the dumping chamber by means of either steam coils or by electricity. This action facilitates the separation of the foreign matter by reducing the viscosity of the oil. The bags may be removed and cleaned at intervals depending upon the amount of contamination. It is very important that filter bags or any other filter medium be of such nature that it can be cleaned, or else be inexpensive enough to permit throwing away.

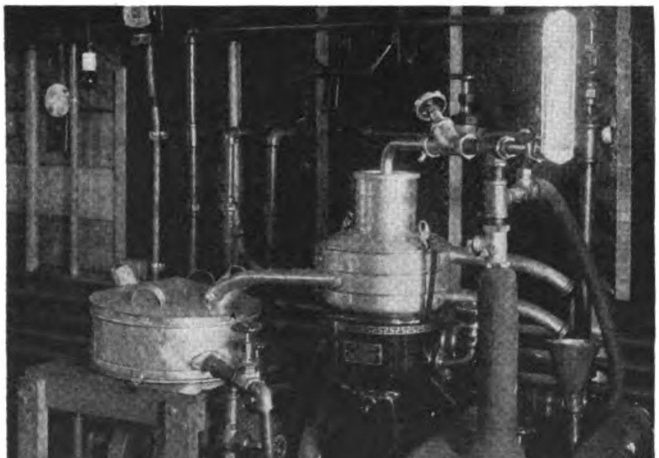
These filters are made of closely woven material. Screens of cloth with uneven mesh or texture do not give good separation. Also, the rate at which the oil passes through the filter determines to a large extent the quality of oil after treatment. If the oil is forced through too rapidly it is likely to carry some impurities with it. Cabinet-type filters, such as described, are frequently used for the storage of reconditioned oil as well as for the cleansing process.

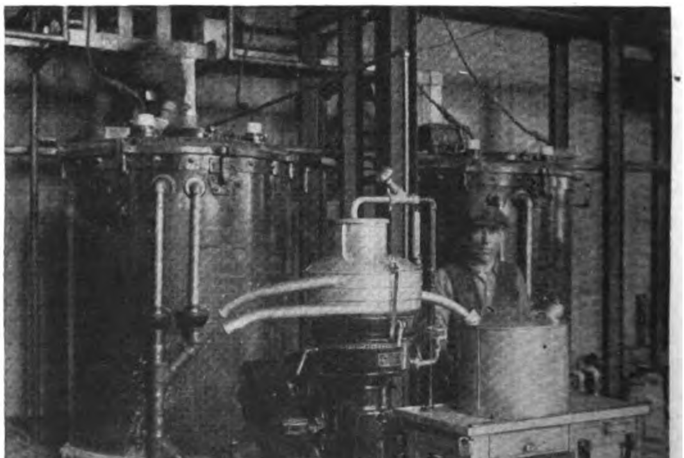
Another type of combination filter and storage tank with the addition of a measuring pump is shown in one of the other illustrations. This is Bowser equipment and is intended for use in industrial plants for the reclamation of oil taken from gear cases, and speed-reducer housings, and bearings. This used oil is poured into a dirty-oil section and passes through the filter into storage.

With any method of reclaiming

Two installations of DeLaval centrifugal separators.

The installation at the left is in the mill of the Long-Bell Lumber Co., Longview, Wash., and is used to recondition the lubricating oil. The installation shown at the right is a portable centrifugal unit handling transformer oils in a Canadian paper mill.

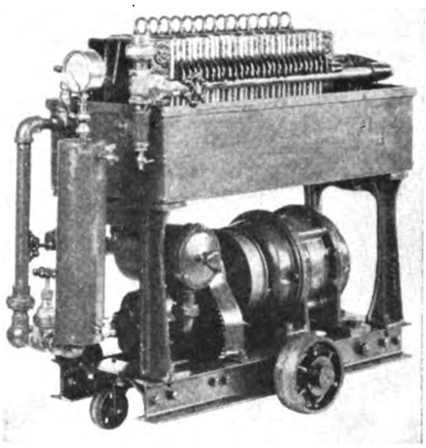




oil it is always best to keep the various grades and types of oil separate. This always assures a more uniform product and more reliable quality. It is especially desirable that blended and animal oils not be mixed in with straight mineral oils.

The method of reconditioning oils by coagulation very frequently combines with it some method of precipitation and filtration. The additional step consists in adding a special coagulant and the entire amount of oil, water, and coagulent is agitated for a short time. This may be done either mechanically or by means of compressed air. After allowing this mixture to settle for a sufficient period the oil and water naturally separate with a layer of sludge between which is made up of the coagulant and the impurities. If the mixture is heated the process is speeded up accordingly. In such equipment provision is usually made to drain off the water and sludge and allow the oil to overflow at the top into storage or through some filtering medium. Equipment using coagulants is generally of a batch type instead of being continuous as the precipitation and filtration methods previously described. The batch type equipment is so called because a quantity or batch of oil is treated as a unit, instead of adding small quantities and withdrawing as desired. The oil must be handled in quantities because it requires time for the coagulated oil to settle and separate after the mixing process.

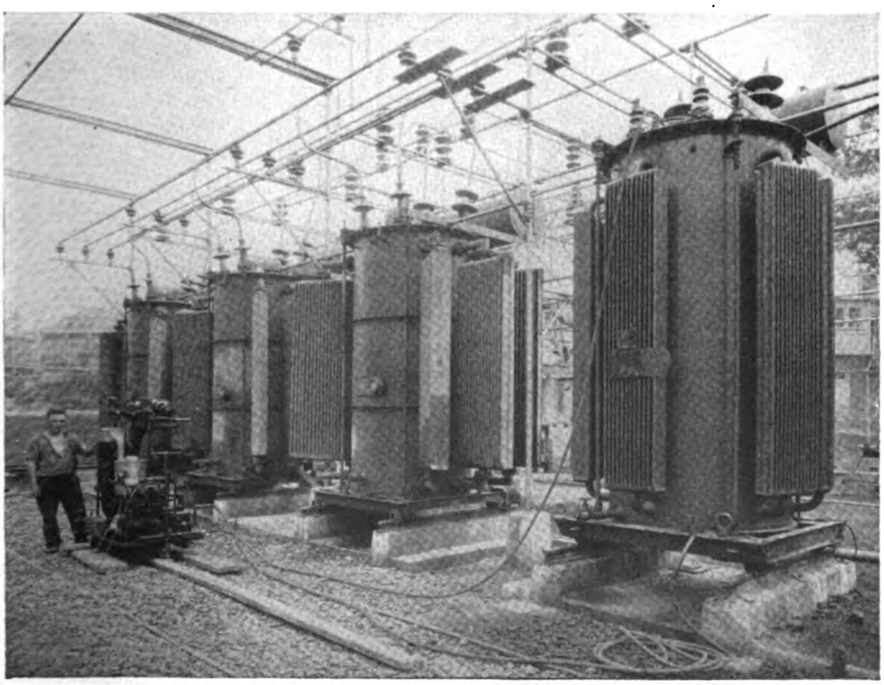
Because of the rapidity and ease of handling large quantities of oil, centrifugal separators are very widely used for the clarification of lubricating and other oils. The separation is accomplished by the application of centrifugal force which separates the oil from the impurities, due to their difference in specific gravity. Heavy oils are usually heated before treatment by electric heaters or steam coils.



Portable unit for reconditioning transformer and other insulating oils.

This is a General Electric Type FP-10 oil drier and blotter filter press with air bell for testing suction piping. This device is also frequently used in connection with a De Laval centrifugal separator.

With the increasing use of the circulation method of lubrication, in which a quantity of the lubricant is circulated continuously through the bearings, industrial men have found it necessary to include some of these methods of reconditioning either as a part of the circulating system or as an adjunct to it. This is quite common in connection with turbines and turbine-driven generator sets, motor-generator sets, gear housings, particularly in some of the more modern steel mills, paper mill bearings, especially on the calendar rolls, and other units. The amount and frequency of the reconditioning as well as the method used depends to a large extent upon the operating conditions. Frequently it is also necessary to add a cooling system to bring the temperature of the oil down to normal.



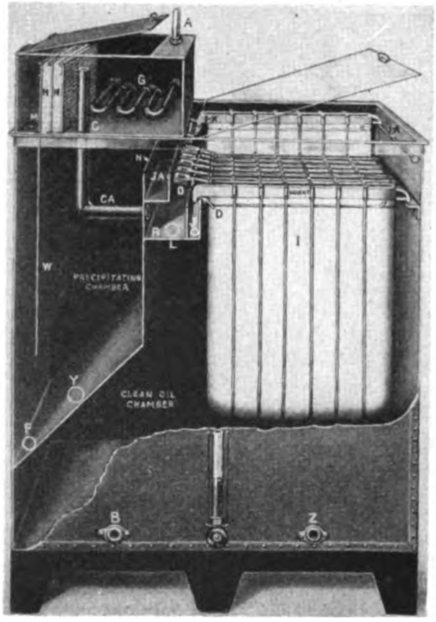
Here the oil in the tank of a 1,665-kva. transformer is being circulated through the centrifugal separator of a Sharples portable unit.

When the oil is badly contaminated or where the requirements of the operating conditions are such as to necessitate absolute freedom from contamination, the oil is treated continuously in that it all passes through the clarifying equipment and is reconditioned before it is used again. This method has its limitations in that practically all methods of reconditioning, except by centrifugal separation, require considerable time. In any case, equipment must be provided which will have a capacity equal to the circulation. Also, for large units the amount of oil handled would be considerable and the equipment necessary to purify it would be expensive.

As it is seldom necessary to purify the oil at each pass, the more common practice is to have a definite percentage of the oil pass through the reconditioning equipment continuously and the remainder recirculated. In practically all circulating systems the oil is discharged into and drawn from a reservoir. It is best to withdraw the oil for treatment from the bottom of this, in that the lower strata would naturally contain most of the precipitated materials and the water, or to have a bypass from the pipe line carrying the used oil.

The amount of oil bypassed for reconditioning depends, of course, upon the amount of contamination. Ordinarily, bypassing 10 to 20 per cent is sufficient. Frequently, in such systems, centrifugal separators are placed in this bypass line and operate continuously. Most of the types of equipment for clarifying the oil, such as those employing the filtration or the filtration and precipitation methods, may be used in connection with a continuous bypass.

The batch method of clarification of oil may be used by withdrawing



One of the Nugent lubricating oil filters.

The dirty oil and water enter the filter through pipe *A*, or may be poured in by lifting the lid. The oil then passes over the steam coils *G* (electric heaters may be used if preferred), through the filtering material *H*, and down through the holes *M* back of the baffle plate *W*. The water is removed at *Y* and the oil flows over the weir *N* into trough *JA* and enters the filter bags *I* through the pivotal drips *O*. The oil outlet is through *B*. The filter bags may be removed, cleaned by washing, and replaced.

a definite quantity at a time, cleaning it, putting it back into circulation, and then drawing another batch. This, however, is an intermittent cleaning operation rather than a continuous process.

The batch method of treatment is usually used in connection with the periodic emptying of the entire system, reconditioning of the oil, and replacing it in circulation or in storage. One of the handicaps of this system is that the equipment must be shut down to remove the old oil and replace it with fresh oil. Also, the same amount of oil must be kept in storage unless the equipment is to be shut down for the time required for the reconditioning of the oil. Another of the drawbacks is that the oil may be permitted to go too long between reconditioning periods and become filled with impurities which might have a serious effect upon the bearings. Coagulants, in connection with filters and precipitation, are often used with the so-called batch method of reclaiming oils.

Development work has practically been completed on an entirely new process of reclaiming lubricating oil. This process, which was developed by the General Electric Co. in its laboratories will be licensed for manufacture and distribution by The Hilliard Corporation, Elmira, N. Y. Briefly, the method of reclamation consists of three steps: Particles of dirt and abrasive material are separated from the oil by means of a chemical treatment in the first step. This is followed by passing the oil over a tank of water in which these foreign particles are precipitated. The third step consists of rectifying the oil by passing it over electrically-heated plates, automatically controlled at the proper temperature, which remove the water, gasoline and any other objectionable diluents that may be present.

It is stated that this process is practically automatic and requires very little labor or attention. The heat of the rectifying plates as well as the temperature within the machine, are automatically controlled. Although this equipment has not been definitely placed on the market, the machine incorporating the process has been under operation in the laboratory of the General Electric Co. for more than 18 months.

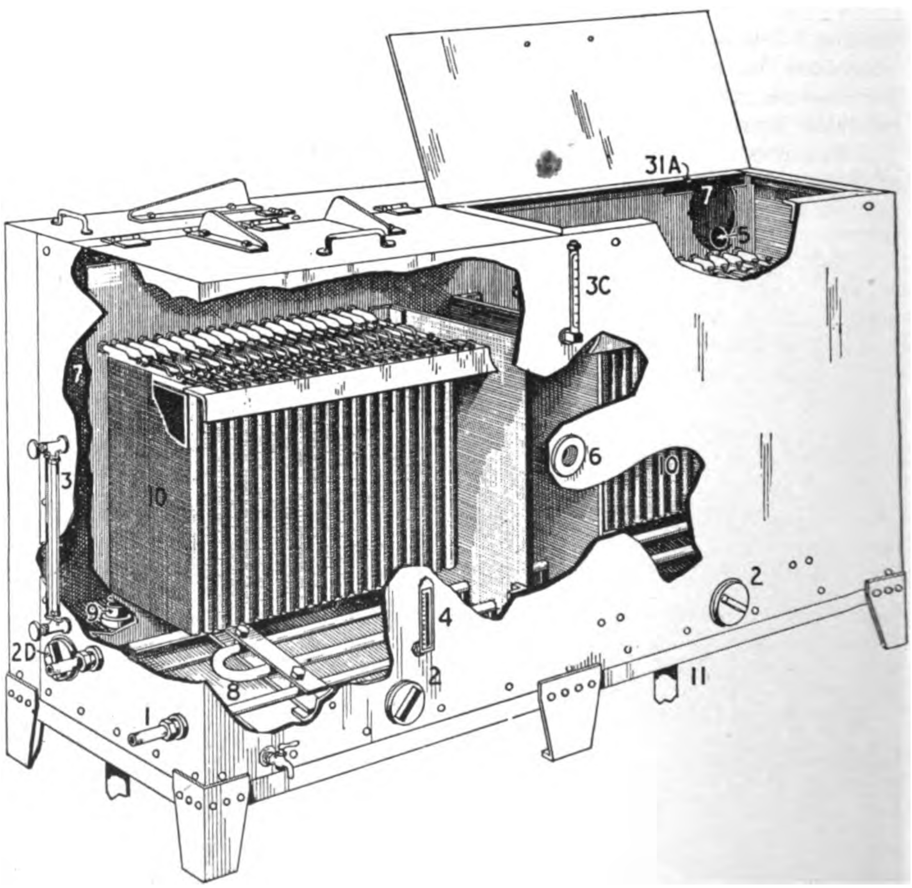
In large industrial plants receiving energy from high-tension lines, proper dehydration of the oil used in transformers and oil switches is of vital importance. The losses resulting from the failure of a bank of transformers, or even of a single unit, are out of all proportion to the cost of insuring against such danger, which is frequently directly due to the continued use of an insulating oil containing moisture, sludge, carbon, or other foreign material.

A good grade of insulating oil forms one of the most satisfactory insulating mediums known, but it suffers deterioration in time, both from the absorption of moisture and the accumulation of dirt and carbon in suspension. Whenever transformer or switch oils are exposed to the atmosphere, a small amount of moisture will be absorbed unless the temperature conditions are just right. From the nature of their service, oils for high-tension switches, circuit breakers and similar apparatus, also accumulate particles of carbon and metal.

The presence of even a small amount of moisture in the oil reduces the dielectric strength. The same is true of particles of carbon, dirt, or other suspended matter,

Details of one type of filter used in steel mill service.

This cut-away view of a Bowser outfit shows the filters and settling tanks. The sloping bottom aids in the removal of the sludge and other precipitated matter.



which, in addition, form undesirable deposits, so that it is necessary, in order to obtain the best service, to employ some method of cleaning and dehydrating the oil from time to time.

Periodic inspection and tests of insulating oil and the dehydrating and purifying of oil that has accumulated moisture or sediment should not be neglected by operators. This is recognized by all who have had experience in the operation of equipment that depends upon insulating oil. Where oil maintenance is systematic, failures of apparatus from burnouts with consequent interruption of service, are minimized, invariably resulting in economy in the use of oil. This is an incidental, but important, advantage.

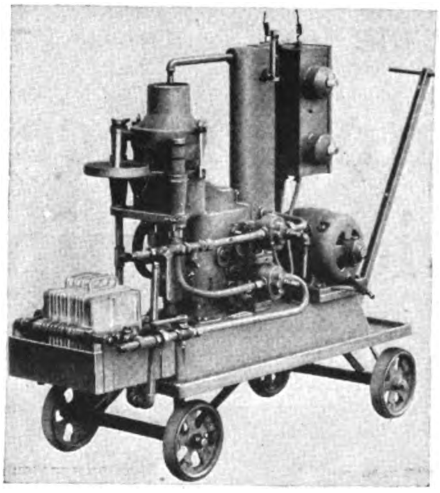
Even new oil should be filtered before being used, to remove any particles of iron rust, scale, or dirt, that may have been detached from the containing vessel during shipment, or moisture accidentally taken up by the oil during handling.

The question of how to remove the impurities from insulating oils has been a serious problem as the clarification of transformer and switch oils presents a somewhat different problem from that in connection with lubricating oils. The consideration of first importance is the removal of all water as well as any sludge and foreign material that may have gotten into the oil. Centrifugal separators and blotter filters, with or without precipitation chambers, are the two types of equipment most commonly used with insulating oils.

In the blotter filter process the oil passes through special blotter or filter papers which absorb the water and also collect any foreign material. Blotters, as soon as they become wet, permit the water to pass through and so must be watched carefully if much moisture is present.

Switch oils offer the additional problem of the removal of the finely divided carbon particles resulting from the quenching of the arc at the time the current is broken.

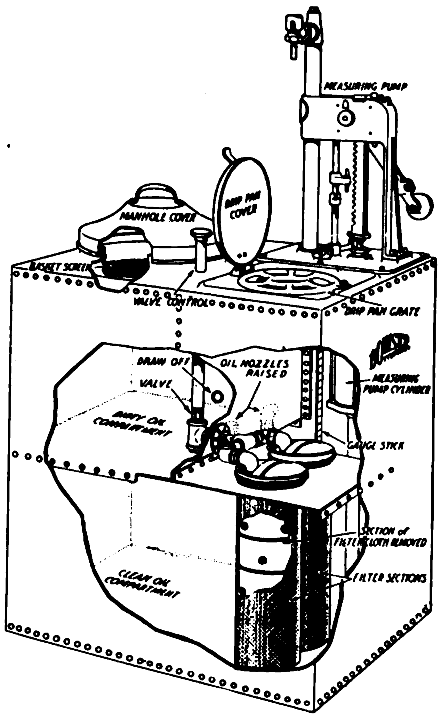
In the Sharples batch process for treatment of insulating oils two reagents are added to the contaminated oils. After the first treatment the oil is passed through a centrifugal separator to remove the water and emulsion containing the impurities. The oil is then given a second treatment and again passed through the separator. Either one or two separators may be used according to the arrangement of the tanks and piping. A typical arrangement using two separators is shown in an accompanying sketch.



Portable continuous centrifugal oil separator with filter press.

This Hydroil unit consists of a centrifugal separator of the bowl type, together with its pump, motor, immersion electric heaters, and filter press, mounted on a truck. The centrifugal separator only is used on lubricating oils. Insulating oils are passed first through the centrifugal separator which removes all water. Finely divided particles in switch oils are removed in the filter press. The capacity of this unit is 100 gal. per hr.

The Hydroil unit combines the centrifugal separator and the blotter press for use in the clarification of switch oils. For transformer oils the centrifugal separator is used alone. The switch oil first passes through the centrifugal separator which removes the water and practically all of the other impurities. It then passes through the blotter filter, which has a much longer useful life because the water has already been removed, and so the papers can be used longer because they remove only the very fine carbon and copper particles which were too minute to be separated centrifugally.



Combination filtering and storage unit for comparatively small quantities of oil.

This Bowser unit receives the dirty oil through a basket screen in the dirty-oil compartment. From this it passes through the filters into the clean-oil compartment. The unit will hold 13½ gal. of dirty oil and 30 gal. of clean oil. When bearings, gear housings, or other oil reservoirs are emptied, the oil is poured into this unit and fresh oil drawn out to refill the oil containers.

The De Laval centrifugal separator is also used in many cases in connection with a General Electric blotter filter.

In the dehydration of transformer oils a commonly used method is to connect the centrifugal separator to the transformer and circulate the oil through the separator and back into the transformer. The quantity passed through the separator should be sufficiently greater than the capacity of the transformer to insure that all the oil has passed through and been clarified.

If desired, however, the transformer can be emptied into a storage tank, the oil purified, and either placed back into the transformer or into storage. This is the process commonly followed when the transformer case is emptied for cleaning or inspection, or for repairs. The frequency of treatment depends upon the conditions under which the electrical equipment operates.

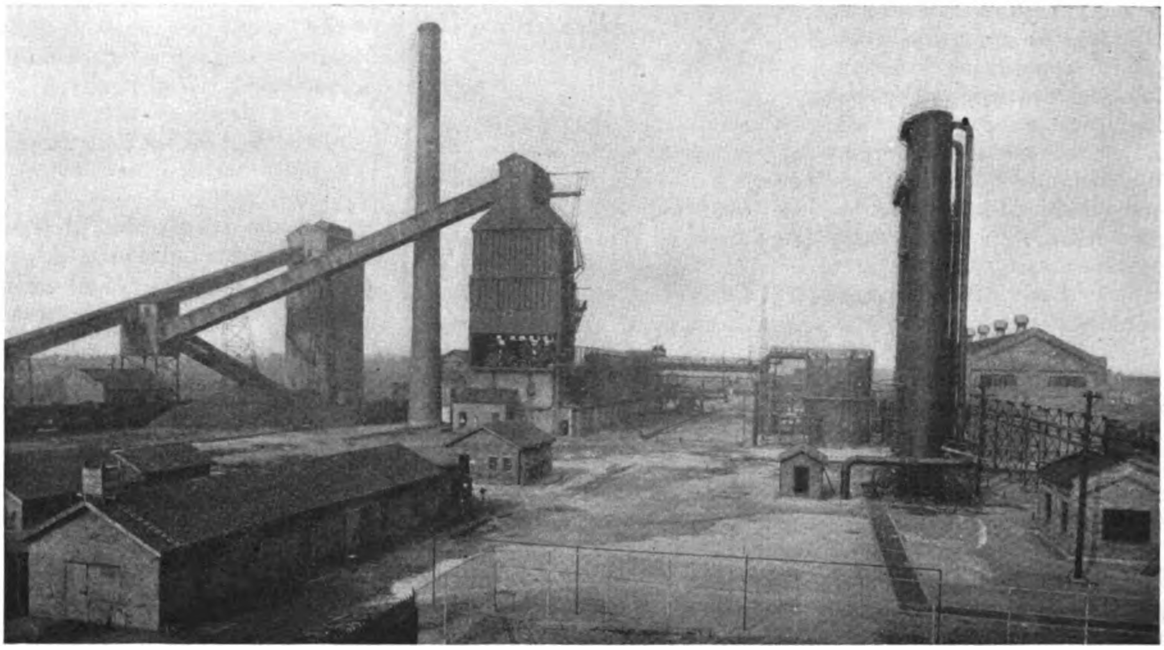
The ever-increasing tendency to use straight mineral oils in the lubrication of all types of steel mill drives and other applications has been an important influence in insuring industrial engineers that the quailty of the oil after reconditioning would be such that it could be used with comparative safety.

EDITOR'S NOTE: Acknowledgment is made to the following companies for illustrations and information used in the preparation of this article: Bousman Mfg. Co., Grand Rapids, Mich.; S. F. Bowser & Co., Fort Wayne, Ind.; The Burt Mfg. Co., Akron, Ohio; The De Laval Separator Co., New York, N. Y.; DeLavergne Machine Co., New York, N. Y.; The Elliott Co., Jeanette, Pa.; Famous Filter Co., St. Louis, Mo.; General Electric Co., Schenectady, N. Y.; Hilliard Corp., Elmira, N. Y.; Hydroil Sales Corp., Lebanon, Ind.; Wm. W. Nugent & Co., Chicago, Ill.; Sharples Specialty Co., New York, N. Y., and Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Organization and routine for

Maintenance of Electrical Equipment

in a small plant



Byproduct coke plant with the Koppers ovens and some of the coal-handling equipment in the plant of the Trumbull-Cliffs Furnace Co.

By O. C. CALLOW
Chief Electrician, The Trumbull-Cliffs Furnace Co., Warren, Ohio

IN THESE days of close competition and high labor costs, a careful study of each department of an industrial plant is necessary from time to time in order to determine whether it is operating on the most efficient basis possible. A study of this character may well be extended to include the maintenance department of the plant. When such an investigation is being made several considerations must be kept in mind in determining the efficiency with which the work is handled. One of these considerations relates to the number of men required. This will depend on:

(1) Type of equipment.

(2) General condition and age.

(3) Importance of continuous operation.

(4) Number of hours plant runs continuously.

(5) How well the plant has been maintained.

(6) General condition of drives.

It is, therefore, impossible to lay down any hard-and-fast rule for the number of men required to maintain a certain amount of equipment or a certain number of motors.

In the following pages, I will discuss briefly the conditions encountered and the electrical organization that is required to maintain a modern blast furnace plant and byproduct coke plant, in the hope that this may be interesting to men in other plants.

The type of equipment used in a plant of this kind has to be rugged and designed to stand very hard service. In fact, there are few if any service conditions that are harder on electrical equipment than those encountered in the iron and steel industry, as about every condition that is detrimental to the equipment is found. The plant referred to in this article consists of coal-handling equipment for one battery of ovens, with the necessary charging, pushing, and coke-handling equipment for the byproduct and motor fuel departments, which have been in continuous operation for nearly three years. In addition there is ore and coal stocking equipment consisting of car dumper, ore bridge and transfer cars for one 600-ton blast furnace, with stockhouse, cast house, pig machine, ladle house, sinter plant, boiler house, pump house, power house and shops. All of this equipment has been in continuous operation for over five years with the exception of a six-weeks' shutdown three years ago.

The following motors are required to operate this plant:

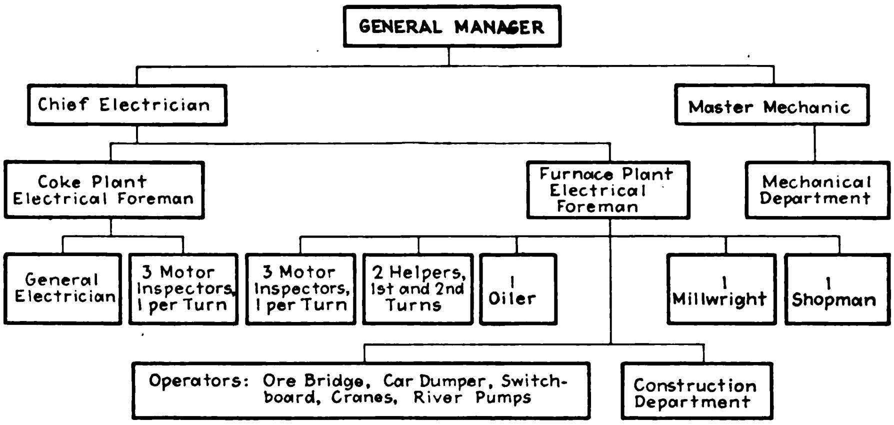
Number of a.c. motors	50
Number of d.c. motors	131
Total number of motors	181
Connected hp. of a.c. motors	2,168
Connected hp. of d.c. motors	3,037
Total connected hp.	5,205

The generating equipment for

these motors consists of 7,000 kw. in steam turbines, 1,500 kw. in motor generators at the furnace, and 300 kw. at the coke plant.

At the coke plant the Electrical Department takes care of the electrical apparatus only, their responsibility ceasing at the motor pinion. The Mechanical Department takes care of the remainder of the maintenance work. Also, all of the operators are directly under the supervision of the Operating Department. A very small electrical maintenance department is, therefore, possible.

At the furnace plant the Electrical Department takes care of the maintenance of all electrical equipment including the motor pinions and couplings, and is responsible for the mechanical maintenance, exclusive of cables and buckets, on three cranes, the ore bridge, car dumper, and skip hoist. All crane operators, bridge, and pump operators also come under the supervision of this department.



The organization of the Electrical Department is shown on this chart.

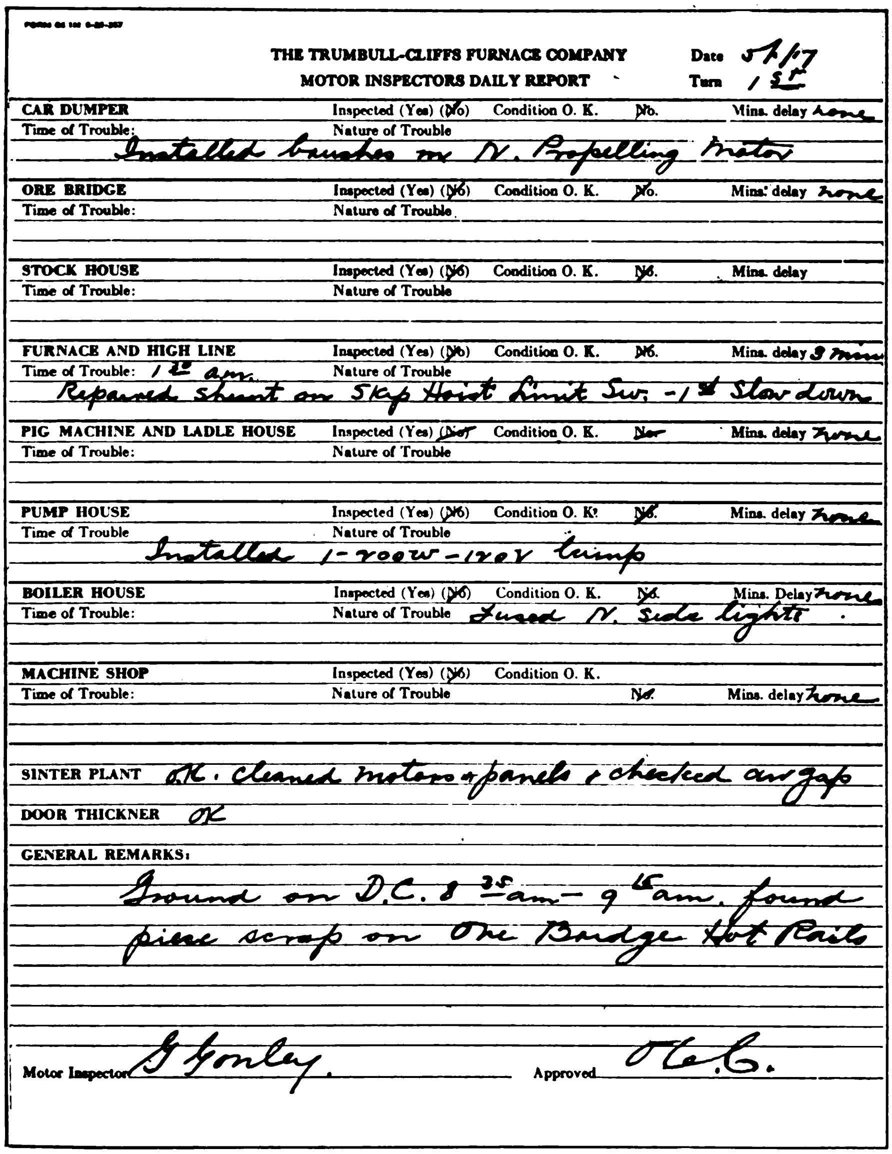
The accompanying chart shows the entire electrical organization. As will be seen, five men are engaged in electrical maintenance work at the coke plant and nine men on electrical and mechanical maintenance at the blast furnace. These fourteen men take care of the 181 motors 24-hr. a day, 365 days a year.

Close co-operation is necessary between the mechanical and electrical departments in a plant of this size as these departments must work hand in hand. For large jobs on the ore bridge, car dumper, and the like, the Mechanical Department supplies what rigging is necessary and also gives help on the heaviest work, such as changing drums and wheels, and riveting.

Practically all of the equipment in these plants operates on what we will call a continuous cycle. For example, a coke pusher pushes an oven every 15 min. Between pushes it levels freshly charged ovens, and handles the oven doors. This cycle is continuous 365 days a year, barring breakdowns. Another instance is a furnace skip hoist. As long as the furnace is in blast the skip hoist must be putting up stock. There are short periods of time when the furnace is full that the hoist is down; otherwise, it may be considered to be operating on a continuous cycle. Failure of the skip to operate means slack wind on the furnace, with consequent loss of tonnage and bad effect on the furnace operators.

To inspect properly maintained equipment operating on a continuous cycle is somewhat difficult, more so than is the case when the plant is shut down over the week end, when a thorough inspection can be given and plenty of time is available for repairs. In our case inspections must be made daily between operations and the inspector must watch his chance, so as not to interfere with the operating schedule. Each motor inspector fills out a report, shown in the illustration, at the left giving the kind

Here is the report form that each motor inspector fills out daily.



THE TRUMBULL-CLIFFS FURNACE COMPANY
MOTOR INSPECTORS DAILY REPORT
Date 5/7/27
Turn 1st

CAR DUMPER — Inspected (Yes) (~~No~~) Condition O. K. ~~No.~~ Mins. delay none
Time of Trouble: Nature of Trouble
Installed brushes on N. Propelling motor

ORE BRIDGE — Inspected (Yes) (~~No~~) Condition O. K. ~~No.~~ Mins. delay none
Time of Trouble: Nature of Trouble

STOCK HOUSE — Inspected (Yes) (~~No~~) Condition O. K. ~~No.~~ Mins. delay
Time of Trouble: Nature of Trouble

FURNACE AND HIGH LINE — Inspected (Yes) (~~No~~) Condition O. K. ~~No.~~ Mins. delay 3 min
Time of Trouble: 1 am. Nature of Trouble
Repaired shunt on Skip Hoist Limit Sw. - 1st Slow down

PIG MACHINE AND LADLE HOUSE — Inspected (Yes) (~~No~~) Condition O. K. ~~No~~ Mins. delay none
Time of Trouble: Nature of Trouble

PUMP HOUSE — Inspected (Yes) (~~No~~) Condition O. K. ~~No.~~ Mins. delay none
Time of Trouble Nature of Trouble
Installed 1-200W-120V lamp

BOILER HOUSE — Inspected (Yes) (~~No~~) Condition O. K. ~~No.~~ Mins. Delay none
Time of Trouble: Nature of Trouble Fused N. Side lights

MACHINE SHOP — Inspected (Yes) (~~No~~) Condition O. K. ~~No.~~ Mins. delay none
Time of Trouble: Nature of Trouble

SINTER PLANT OK. Cleaned motors & panels & checked air gap

DOOR THICKNER OK

GENERAL REMARKS:
Ground on D.C. 8 35 am - 9 45 am. found piece scrap on Ore Bridge Hot Rails

Motor Inspector G. Gonley. Approved O. C. C.

and location of the equipment, nature of trouble found, if any, time lost, and repairs or adjustments made. With the help of these daily reports we are enabled to keep a very close check on the condition and performance of every piece of equipment.

When a repair becomes necessary, all preparations must be made beforehand so that the least possible time will be lost while the work is being done. In some instances production is quickened up a little ahead of time in order to gain time for the repair.

Repair jobs are often held up until a shutdown is required for other reasons, such as changing cables or other mechanical work; then with the whole force thrown onto one piece of equipment the repair job is quickly put through.

To carry out successfully any system of handling maintenance work the inspections must be thorough and the department head must know the exact condition of his equipment at all times. He must have a list of the repair work that is required to be done on a certain piece of equipment; he must watch to see that the condition of any equipment needing repair does not become too serious and cause a breakdown; and he must use his judgment as to when he can have the work done without causing a delay to production.

In the case of small motors of which there are a good many duplicates, a number of spares are kept on hand. If inspection shows that one of these motors in service has worn bearings, bad commutator, or is in a dirty condition and may give trouble, the spare is made ready for installation with a new or spare pinion, and a change is made at the first favorable opportunity. The replaced motor is then taken to the electric shop and given a thorough overhauling. When this work is completed, the motor is given a running test so that when it is installed in the place of another, it is known to be as good as new.

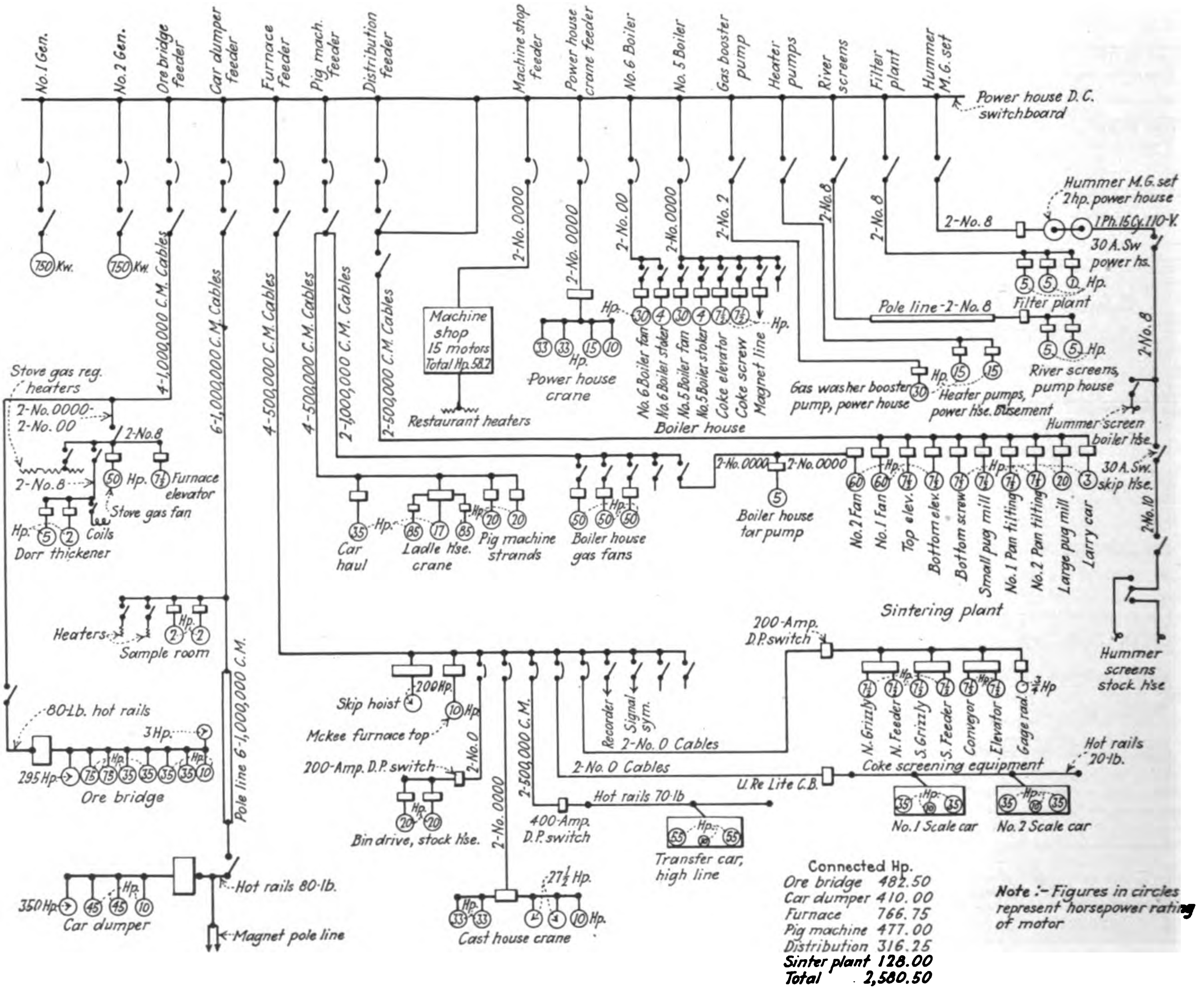
If it is found that a winding is in bad condition, a new one is put in, instead of making a patch job that may break down and cause a bad delay.

All rewinding is taken care of by one man in the repair shop; new coils are purchased from the manufacturer of the motor and installed by our winder. Bearings are babbitted by the Electrical Department force. All millwright and machine work is done in the machine shop, the machinist working under orders from the head of the Electrical Department while he is engaged on such work.

We keep a record card, one of which is shown on page 275, for every motor. This card contains complete data on the motor, including the nature of repairs needed, and their cost.

When cases of trouble occur every effort is made to improve the condi-

Layout of direct-current power circuits in blast furnace plant.



tions causing the trouble. In one case where considerable bearing trouble was encountered with the motors on a slag pit crane, the installation of roller bearings on all of the motors on this crane has entirely eliminated this trouble. The value of this policy of clearing up sources of trouble is shown by the fact that after five years of continuous operation less repair jobs were handled in the past 12 months than ever before.

Ground lights are installed at various points around the plant, on both the a.c. and d.c. circuits. As soon as a ground appears it is the motor inspector's job to locate it and get it cleared before serious trouble occurs. The installation of a recording voltmeter is being considered so that a check on this important condition may be available at all times.

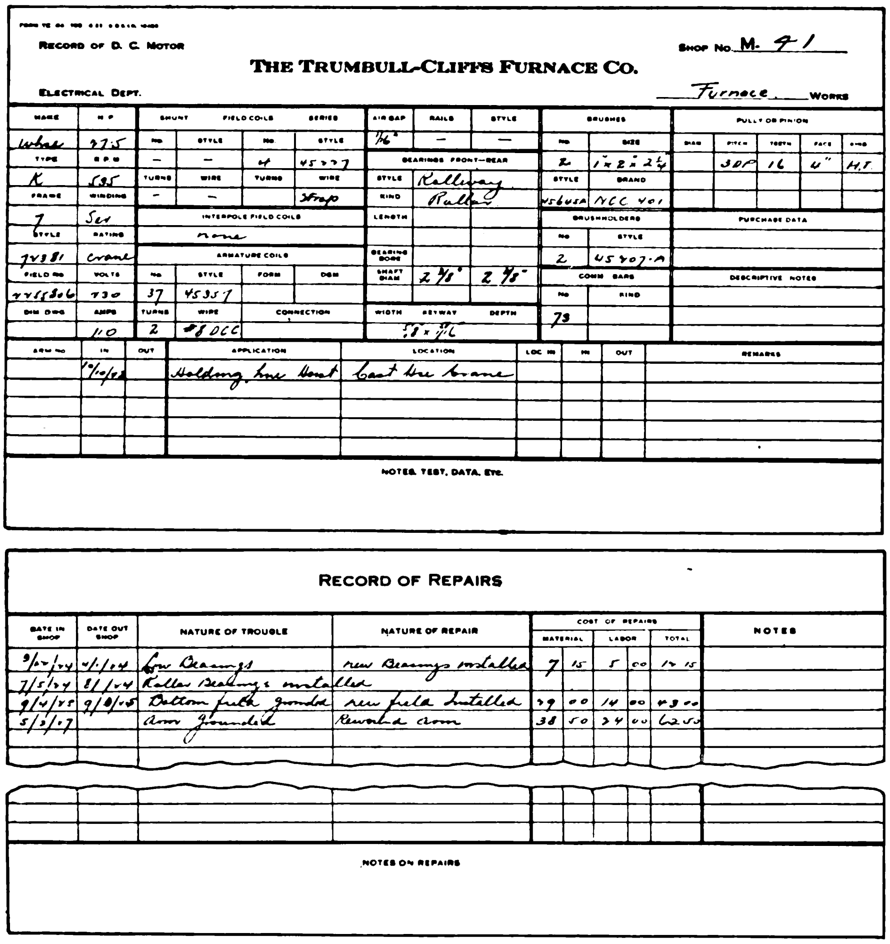
A blueprint of the feeder circuits is given to each inspector so that he can become familiar with all equipment connected to each circuit. We find that this helps in locating grounds. One of the illustrations shows the d.c. circuits in the blast furnace plant. An insulation resistance test is made with a Megger at certain times, or when any equipment is down for repairs. A record is kept of these readings.

Most insulation failures on motors can be traced down to two chief causes: overheating, causing baking of motors, or deterioration due to dirt, oil, or fumes. The latter are ever present in a coke and furnace plant in the form of fine coal and coke dust, flue dust, and flake graphite. All of these are very bad for insulation inasmuch as they are good conductors themselves and if allowed to accumulate will quickly cause trouble. For this reason, a large proportion of our motors are totally enclosed.

A large amount of trouble can be prevented if the right kind of men are employed as inspectors and properly trained to handle their jobs. A good man soon finds that the more carefully he inspects and keeps up the equipment for which he is responsible, the less work he has to do.

It is my opinion that a bonus scheme could be worked out for nearly all maintenance departments, arranged so that the inspectors and maintenance men will receive a bonus based either upon the decrease in maintenance costs for the department as compared with previous years, or upon the decrease in the number of breakdowns occurring. A carefully-planned and fair scheme of this kind would insure the maximum of co-operation and effort.

A record card like this is kept for each motor in the plant.



Steel Mill Power Drives

(Continued from page 255)

been developed which yield more light per unit of current consumption.

Roll Heaters—That there are now 164 roll heaters operating in the sheet and tin mills of 19 plants is the report received from Freyn Engineering Co. Results in these plants show that the use of electric roll heaters has increased first-turn production about one-third and decreased scrap loss by 10 per cent.

The increase in production is due to the fact that rolling can be started on orders of any gage or width within the capacity of the mill, practically from the first sheet bar fed into the rolls. This eliminates the necessity of warming up iron. As a result the production on the first turn approaches midweek values.

Electric Furnaces—In the field of electric arc melting furnace equipment, the general tendency is to build furnaces of larger size and provide for higher rates of power input. This has been made possible by the use of three-voltage switching.

When the cold charge is first placed in the furnace, it is capable of absorbing heat at a higher rate than after it has become molten; that is, with the cool metal the temperature of the furnace walls is not increased beyond the permissible value by the increase in the rate of energy input; hence a higher voltage can be used than would be used later in the heat.

When the temperature of the walls has become as high as permissible, it it possible to switch to the next lower voltage tap and supply energy to the furnace at a lower rate. Finally, when this rate of energy input is also undesirably high, it is possible to switch to a still lower furnace voltage and reduced energy imput.

The electric furnace has become an important factor in the steel industry in the production of tool and alloy steels. Among the largest of these recently installed are two 15-ton and a 25-ton Heroult furnace. A Westinghouse arc furnace regulator is used with these furnaces.

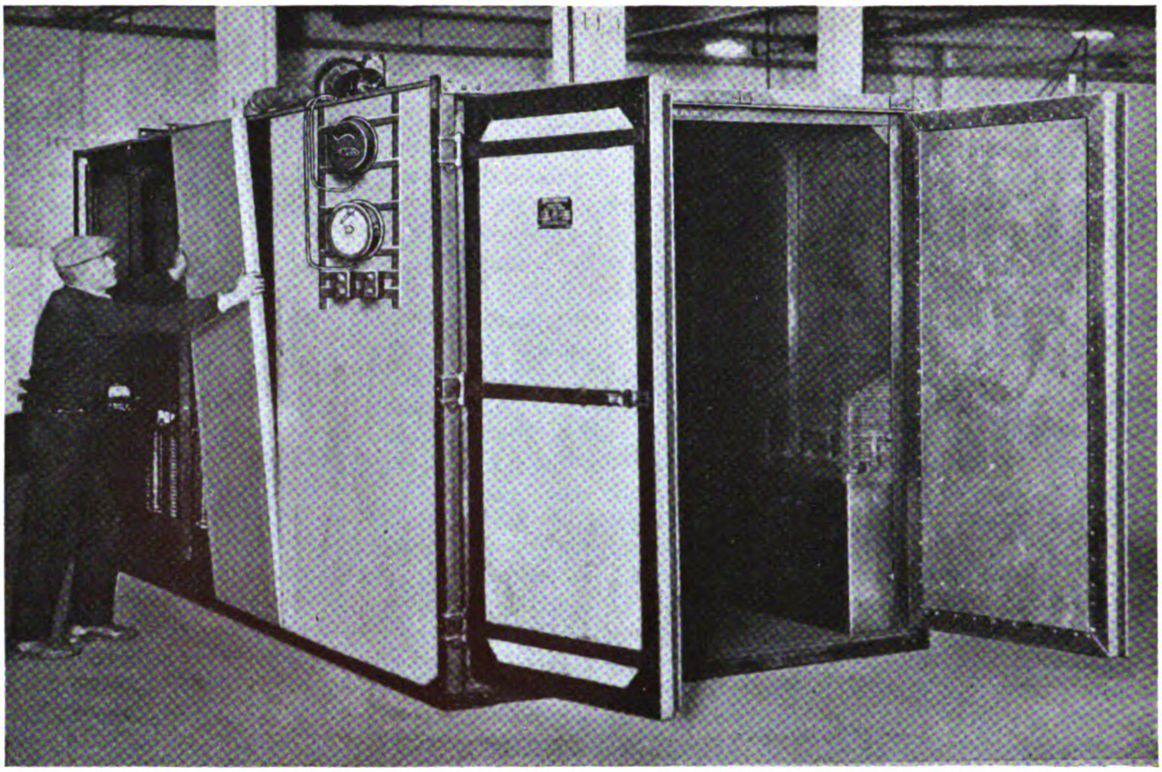


Fig. 1—The ventilating equipment for this box-type oven is controlled from a push button on the side-wall rack, which carries the thermostat and temperature indicator. A second push-button station controls the heating elements.

Low-Temperature Electric Ovens

for industrial applications

By EDWIN FLEISCHMANN

Industrial Heating Engineer,
Westinghouse Electric and Manufacturing Co.,
East Pittsburgh, Pa.

ELECTRICALLY-HEATED ovens designed for temperatures below 700 deg. F. have been used for baking bread, or japans, carrying on drying processes of many kinds and performing numerous other similar operations for years with great success. The economy of electric heat as compared with other fuels decreases very decidedly as the temperature goes down, but there are often other factors which take precedence over fuel cost in such work, so that electricity is frequently the only heating means considered. Reduction in fire hazard, fewer rejections, and less shrinkage are among the factors to be taken into account.

In the average electric oven, the simplicity of construction is a point to be borne in mind constantly. The temperatures are so low that with the exception of the heating elements, steel may be used for all parts of the oven. The only important and somewhat technical phase of oven work is the ventilation, of which more will be said later.

Fundamentally, an electric oven consists of a supporting structure with thermally-insulated walls, a means of getting charges into and out of the enclosure, a heater of some sort within the oven, and, when necessary, suitable ventilating equipment.

In choosing an electric oven, the floor space available will determine whether a box type or conveyor unit can be used, while the amount of production will indicate whether a conveyor oven would be justified. The operation which is to be carried on in the oven will also have a very great bearing upon the character of the equipment. It is obvious that one would scarcely use a conveyor type oven for baking cores or armatures, although, at the present time the former is being done successfully. Not only must the material to be baked or dried have careful consideration, but the duration of the complete cycle also. While cycles of short duration lend themselves more readily to continuous working, very long cycles will be best suited to batch production in box-type ovens.

The kind of heating to be carried on in the oven will determine as well the amount and kind of ventilation required, the method of handling the material, and the installed electrical capacity. The flexibility of the electric oven makes it possible to place small units at strategic points, where they will work best into the production arrangements of the shop. By this means, economies may be effected by reducing the handling costs.

When small, box-type ovens are employed, it is always advisable to make use of standard sizes, of which there are a large number available,

and it is not serious nor disadvantageous to have an oven slightly too large for the work being done, unless the installed capacity is entirely out of proportion. The latter, however, can usually be adjusted by the manufacturer to suit the existing conditions, so that, an oven is obtained at a price, which would be much more reasonable than for one specially constructed. Although electric ovens are comparatively simple to construct, many manufacturers are inexperienced in the arrangement of heating elements, thermal insulation, and in the proper provision for ventilation. If, however, these three factors are checked carefully there is no reason why any manufacturer of ovens cannot make a satisfactory electric oven. Too much stress cannot be laid on the importance of care in design with regard to these three matters.

Ordinarily the framework of ovens is made of structural steel, consisting of angles and channels, which support the wall panels. Careful bracing is necessary to insure sturdiness of the framework, so that there will be no warping under the influence of the heating and cooling of the walls. Although the outside surface of the walls normally runs at a very conservative temperature, silght changes due to heating and cooling often serve to weaken the supporting structure, so that the oven becomes unsteady. This is particularly important where the work runs into or through the oven upon a rail, or conveyor, supported from the roof or on the floor.

The floor contruction is of very great importance in ovens which employ racks mounted on trucks, or wherever heavy loads will rest upon it. It is usually supported upon channel irons, closely spaced, and so arranged that the amount of through-metal is a minimum. A heavy boiler plate covering serves as the floor itself. Where tracks are used they are supported directly on the channels which rest upon the ground or shop floor. Insulation is applied between the tracks and the channel irons to reduce the losses from the bottom of the oven.

The most commonly used substance for the insulation of low-temperature ovens is mineral wool, a fibrous material which results when a blast of steam is sent through molten slag or rock. It is made up in several forms, and can be obtained either in bulk, or in felted form, in slabs of convenient dimensions.

Other insulations are sometimes employed but as mineral wool has a very low coefficient of thermal conductivity, it is in almost universal use. At temperatures up to 200 deg. F., 1 or 2 in. of thickness are generally sufficient; between 200 deg. F. and 400 deg. F,, 3 in. will be ample; and from 400 deg. F. to 700 deg. F. at least 4 in. should be used on ovens of any considerable size. The thickness will depend not only upon the temperature, but also upon the size of the oven, as the losses are directly proportional to the area of the outside surfaces.

In most cases, the walls of ovens are made up of a number of panels, each panel consisting of a structural iron frame with sheet metal coverings, between which is the mineral wool insulation. There are many different types of panels now in use, the chief feature of all being the reduction of losses, either partially, or wholly by the elimination of through-metal. It is evident that reducing the cross-section of the metal which passes through the panels from the heated enclosure on the inside to the room temperature on the outside, reduces the amount of heat which will be lost through the walls. It is wise, therefore, to make the wall panels in such a way as to keep the through-metal losses at a minimum.

On the other hand, the panels must be braced against unequal expansion and contraction to which they will be subjected by the high temperature inside the oven and the low temperature without.

The wall panels and roof panels are usually assembled upon the structural framework, when the oven is set up in the shop, in the manner shown in Fig. 1. The panel construction makes the assembly simple and expeditious.

When doors are used, it is well to be sure that they are tight fitting and provided with a positive latch which clamps the doors shut and holds them so during heating. Furthermore, they must be braced to withstand distortion due both to unequal heating and to the stresses incident to opening and closing. It is also important that the body of the oven be rigid enough to withstand these shocks, and to hold the weight of the door when open. If there are to be doors at both ends of the oven, firm bracing of the body of the oven is especially necessary.

The width of the oven determines whether single or double doors will be used. It is impracticable, however, to use single doors on large ovens because of their weight, and the fact, that the swing will be so large that too much additional floor space will be taken up by the equipment.

The insulation on the doors should be of the same thickness as the walls. Although there will always be larger

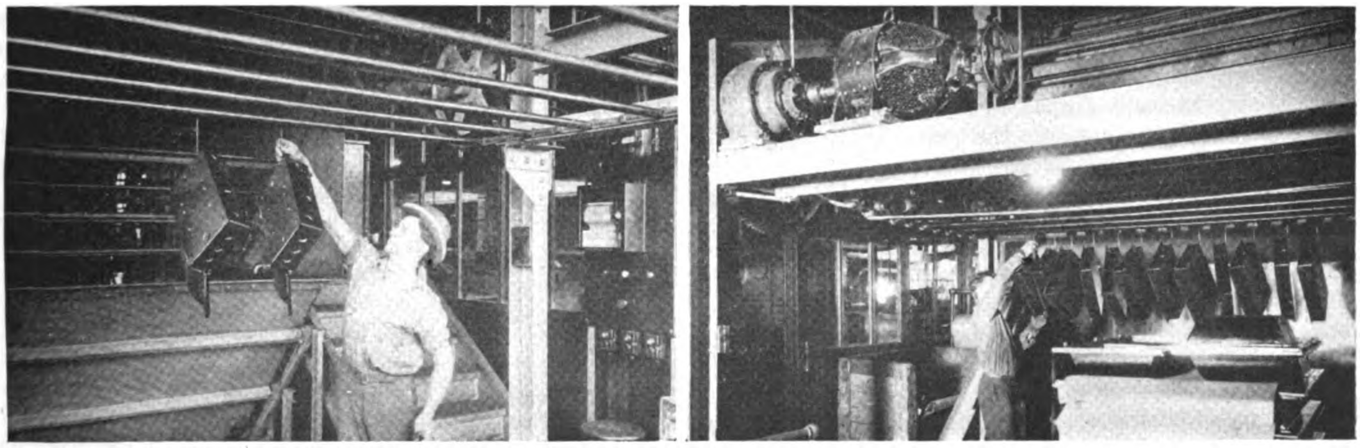


Fig. 2—The modified A type continuous-conveyor, japanning oven. The view at the left shows the charging end, conveyor, dipping tank, and control panel with temperature recording instrument. The view at the right shows the exit end where the finished work is being removed from the conveyor. The conveyor drive equipment is shown mounted overhead.

losses around the door, the face of it is subject to the same conditions as the walls of the oven, and it is well to conserve as much heat as possible. As a further precaution, switches should be provided which cut off the current whenever the door is opened. This not only saves electrical energy, at a time when it would otherwise be wasted, but also protects the workmen from injury during loading and unloading.

In very small ovens, no means of holding the charge are provided, except where a number of shelf supports, usually movable are mounted on each side of the oven. Upon these are placed or hung, shelves, rods, or racks of any kind suitable to the work.

In larger ovens it is frequently desirable to load the racks outside the oven. In this case, the load is moved into the chamber and out again by means of a lift-truck; sometimes the whole charge is mounted on a car. The latter is often employed for heavy work such as railway motor armatures.

It is important, that all parts of racks or trucks to be used in ovens be made of metal. Steel is commonly used and is most satisfactory at oven temperatures. All joints should be welded or riveted.

The various types of conveyor ovens present problems in themselves. Here the work is hung on moving racks and carried into the oven automatically or partly so. The simplest batch-type conveyor oven is the so-called semi-continuous conveyor unit. Where production is on a small scale, this type of oven is often preferred. The work is hung on the conveyor at one end, while one charge is heating. The cold charge is pushed into the oven, and the baked charge comes out the opposite end to be unloaded. The operation can be made continuous or not, as fluctuations in the production rate dictate.

Finally, the full-continuous conveyor type is still in use for large production operations, where the work is automatically dipped, drained and baked by being hung on the conveyor cold at one end as shown in Fig. 2, and removed, completely baked, at the other end.

Ovens of this type are made in various shapes, varying from the old "tunnel" style, of which many are still in use, to the latest A type or modified A type, of which the oven shown in Fig. 2 is an example. The variations of shape are due chiefly to improvements in economy of operation, by more efficient ventilating arrangements. Another type of construction that has been used successfully, is that in which the work travels in a zig-zag, up-and-down motion through the heating chamber, and finally is brought back to the loading end for discharge.

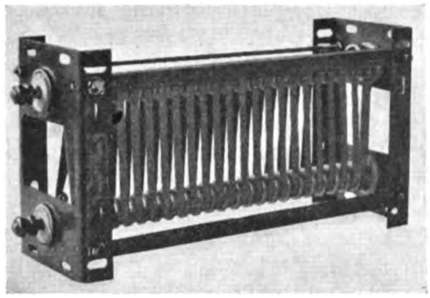


Fig. 3—This is a small convection-type heater for low-temperature electric ovens.

Two projecting rods form the terminals of the heater. Nichrome ribbon is wound on porcelain bushings and uniformly distributed over the entire length.

In general, the arrangement to be selected will be that which most nearly meets all the requirements and limitations imposed. Where the floor space is limited the box-type, semi-continuous conveyor oven may have to be used. The "tunnel" type will be indicated if head-room is restricted, for under these conditions it will be almost impossible to use an A type or modified A type oven.

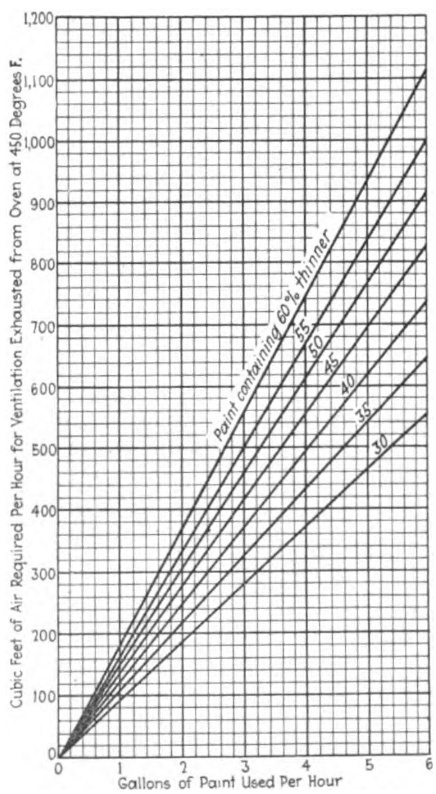


Fig. 4—This chart shows the ventilation required to remove fumes from low temperature ovens.

For oven service a conventional type of low-temperature heater is required, for example, like that shown in Fig. 3, wherein the Nichrome ribbon is uniformly and openly distributed throughout its length, to permit free passage of air through and around the turns. Insulation is ordinarily obtained by means of porcelain bushings mounted on a rod.

A substantial cross-section of ribbon should be used to insure long life; and, although the rating in watts per square inch of peripheral surface of the ribbon is not so vital here as in the case of furnaces, conservatism still means long life. The heater shown in Fig. 3 is rated slightly above 5 watts per square inch, which is considered a safe rating, even at furnace temperatures.

The ribbon should be wound loosely in order to allow for the expansion of the frame under heat, but not so loose as to permit short-circuiting between turns.

In mounting the heaters on the walls or floor of an oven, it is important to make sure that the ribbon is supported at a distance sufficient to prevent grounding. This is ordinarily taken care of by the width of the end frame. The same precaution is needful in regard to protective screening and baffles mounted in front of the heaters. In long heaters, that is, over 2 ft., some means should be employed to keep the spacing of the rods correct. A porcelain spacer is often used midway in the span.

A word of warning is necessary here against the use of asbestos in any form as a means of supporting the heating wire or ribbon. At oven temperatures asbestos gradually dehydrates, becomes powdery, and early in the process loses its electrical insulating property, so that grounds are frequently experienced. The seriousness of this danger appears especially in ovens where volatile vapors are given off from the work, as in japanning. The connection of the nickel-chromium ribbon to the steel terminals of the heater is important because of the unequal expansions of the two metals, when heated.

Interconnection of heating elements in the oven is made by the use of strap-iron connectors and clamps. Cold-rolled steel busbars are also used, and various sizes of clamps are made to suit. It is important that the connections be made by clamping, rather than bolting, or riveting, as provision must be made for the

motion of the busbars under expansion and contraction, without loosening or destroying the electrical connection.

Steel is used for connectors, clamps, and busbars in preference to copper, because it resists oxidation up to approximately 700 deg. F., whereas, copper oxidizes rapidly at fairly low temperatures. As a guide in keeping the temperature of the busbars down to a reasonable and safe value, the accompanying table of current carrying capacities of various usual sizes at different temperatures may be of interest.

As practically all of the heat in electric ovens is carried by convection, that is, through the medium of circulating gas, vapor, or air, heating elements are normally placed as near the floor as possible.

In box-type ovens, they will be placed along the walls in order to be out of the way of trucks and work, and when so arranged the incoming ventilating air is forced through them from below, or from the side, in order to be heated before encountering the work. In some cases, heaters are also mounted in the center of the chamber, in order to equalize the heat distribution.

In conveyor-type ovens, heaters are mounted either on the walls or floor of the oven, but in the latter case they must be carefully covered, especially through the entering sections of the oven, in order to prevent drippings from fouling them. In some of the older continuous-type ovens the distribution of heaters had to be varied in order to obtain the proper temperature zoning.

In the A type, or modified A type, ovens the heaters are mounted on the floor or walls of the elevated section. The work is being pre-heated as it rises to this point, is baked while passing over the heaters, and cooled as it descends to the exit end. In general, the heaters should be arranged so as to give the temperature distribution or cycles of heating required. It is scarcely necessary to concentrate the heat near the doors, as is the case with furnaces, as the ventilation of a continuous oven can be so designed as to compensate satisfactorily for the losses at this point.

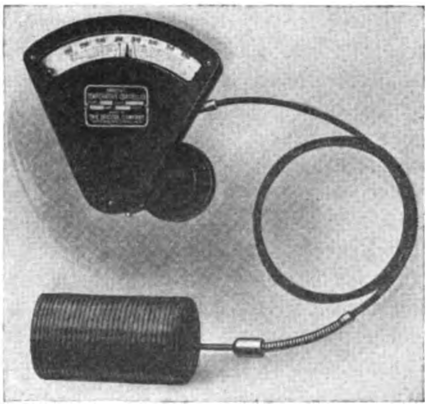


Fig. 5—Here is an electric-contact-type control thermostat with extended bulb.

The coiled bulb is placed in the oven. The contacts are moved by the variation of pressure in a Bourdon tube in the instrument.

One of the most important features of electric oven design is the method used for circulating air through the chamber, which includes the quantity of air exhausted as well. In all japanning operations where the solvents of the paint are volatile materials, such as ether, benzine, or naphtha, the ventilation plays a most important part. For work such as drying or armature baking, natural ventilation is often sufficient. In any case, some circulation if properly directed will improve the temperature distribution in the oven. Without ventilation, the heated air will naturally rise to the top of the oven and be pocketed there while the bottom will be cooler by 100 deg. or more.

In small, box-type ovens for armature baking or light drying jobs, natural ventilation is ordinarily provided, by means of vents along the walls under or behind the heaters, which serve as intakes, and a larger vent in the roof with a damper, so that the outflow of air may be controlled. In order to increase the flow, the exhaust is often connected to a stack, so that a slight draft may be obtained.

Mechanical ventilation is almost always used in larger ovens, and invariably so in conveyor ovens, because the motion of the work makes positive control imperative. The intake is a pipe along the floor under the heaters, and the exhaust is either through a flat pipe along the floor, or from the roof, or both.

The vapors from japans are heavy, so they can be exhausted best along the floor. It is advantageous sometimes to exhaust from both points in order to equalize the temperature distribution, but this will depend largely upon the nature of the work and the character of the charge. Air is taken into the oven through the heaters, and in order to insure its passing over the coils, baffles should be provided in front of them. The importance of careful baffling cannot be over-emphasized, as it affects the entire temperature distribution in the oven, and if skillfully done can greatly increase the useful volume of the oven.

In the latest modified A type ovens, a sort of recuperative ventilating scheme is employed in which the efficiency is materially increased. The hot gases are drawn out of the oven at the entering end, while the cold air enters at the exit end, so that some of the heat of the gases is imparted to the cold work, and in turn the baked parts serve in a measure to heat the incoming air. A very strong suction is required, however, to prevent the gases from coming out into the shop.

The amount of ventilation needed varies in different applications and with different types of ovens. Armature baking requires about 15 changes of air per hour, core baking requires from 20 to 40 changes per hour and ordinary drying processes from 30 to 60 changes.

In armature baking it is not wise

Maximum Safe Capacities in Amperes for Cold-Rolled Steel Busbars

Operating Temperature of Oven Chamber, Deg. F.	Size of Busbar in Inches				
	1 x ¼	1¼ x ¼	1½ x ¼	1¾ x ¼	2 x ¼
200	120	160	200	240	285
250	115	155	195	235	280
300	110	150	190	230	270
350	105	145	185	220	260
400	100	135	175	210	250
450	90	125	165	200	240
500	75	110	150	185	225
550	60	90	125	160	200
600	45	70	100	130	160
650	30	45	65	90	115
700	15	25	30	45	60

to recirculate the air, but for core baking and drying, from one-half to three-quarters of the air may be recirculated. In the case of japanning, or drying paints and lacquers, the number of changes of air depends entirely upon the quantity necessary to keep the concentration of volatile vapor in the oven below the value at which explosion will occur under the prevailing conditions of temperature. There should be no recirculation. The curve shown in Fig. 4 may serve as a safe guide in this respect, for it represents the results of exhaustive research upon the subject.

Whenever forced ventilation is employed the blower should be so mounted that the motor and fan bearings will not be overheated by conduction. It is the usual practice to place the bearings some distance from the fan housing so as to prevent interference with lubrication.

The fan itself, particularly when it is used to exhaust japanning vapors, should be of the straight, paddle-wheel variety for it has been found dangerous to use fans with curved, or Venturi blades because the heavy vapors condense on them and fill up the curves, gradually reducing the effective discharge area, so that the correct volume of air is no longer handled. Oven explosions have been traced to this cause.

Ample ventilation in an oven is necessary, even though it may decrease the efficiency somewhat. Excess ventilation is absolutely essential for such applications as temper-drawing ovens where the temperature distribution is vital.

The control of temperature in electric ovens is accomplished in a manner similar to that employed with in furnaces. The only difference is that a thermostat instead of a pyrometer is used. The thermostat has three electric contacts within it: a low, high, and common. The common contact is set for the temperature at which the instrument is to control, and the other two, a fixed distance apart move in response to the variations of temperature in the oven. When the temperature rises to the desired point the high contact touches the common, causing the oven current to be shut off. The temperature then drops until the low and common contact touch and cause the oven heaters to be energized; and so on, while the oven is in operation.

The bulb of the thermostat, which is placed in the oven, may be either straight or of the extended type, such as shown in Fig. 5. The extended bulb is supposed to give more of an average temperature in the oven, but there seems to be some question as to whether it really does this, or actually gives the maximum temperature it encounters. It is superior to the straight bulb in that the latter gives the temperature at one point only, and controls the oven at that value. The variations which are to be expected in a large oven make this an inaccurate method of control.

The closeness of control to be expected from a given instrument depends entirely upon the physical distance necessary between the contact points and of course, the length of the scale. Variations in temperature scarcely less than 5 deg. F. can be obtained, although on very short range instruments whose contact points are set very close, this may be slightly bettered.

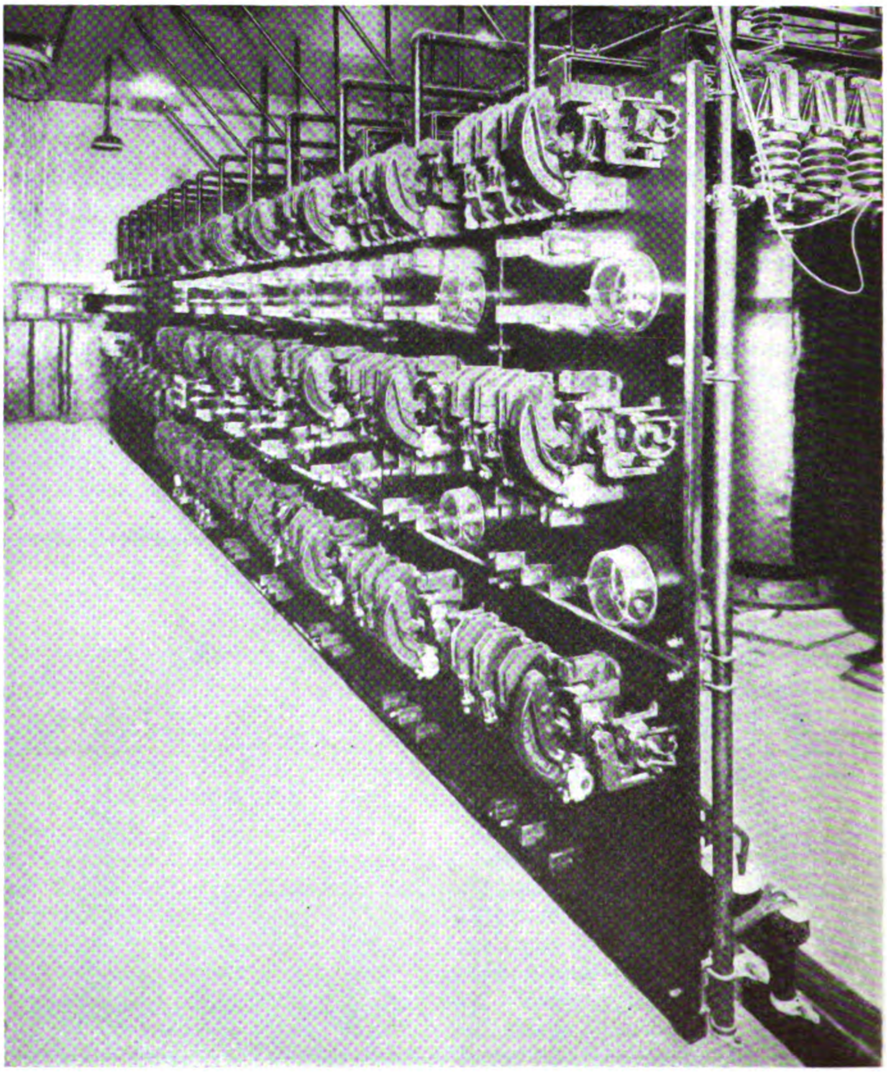
The current to the heaters is turned on and off by the thermostat acting through a relay and main line contactors. These, with fuses or an overload relay, are usually mounted on a slate panel which may be placed in any convenient location. The panels for large ovens are often placed in a room by themselves, as shown in Fig. 6.

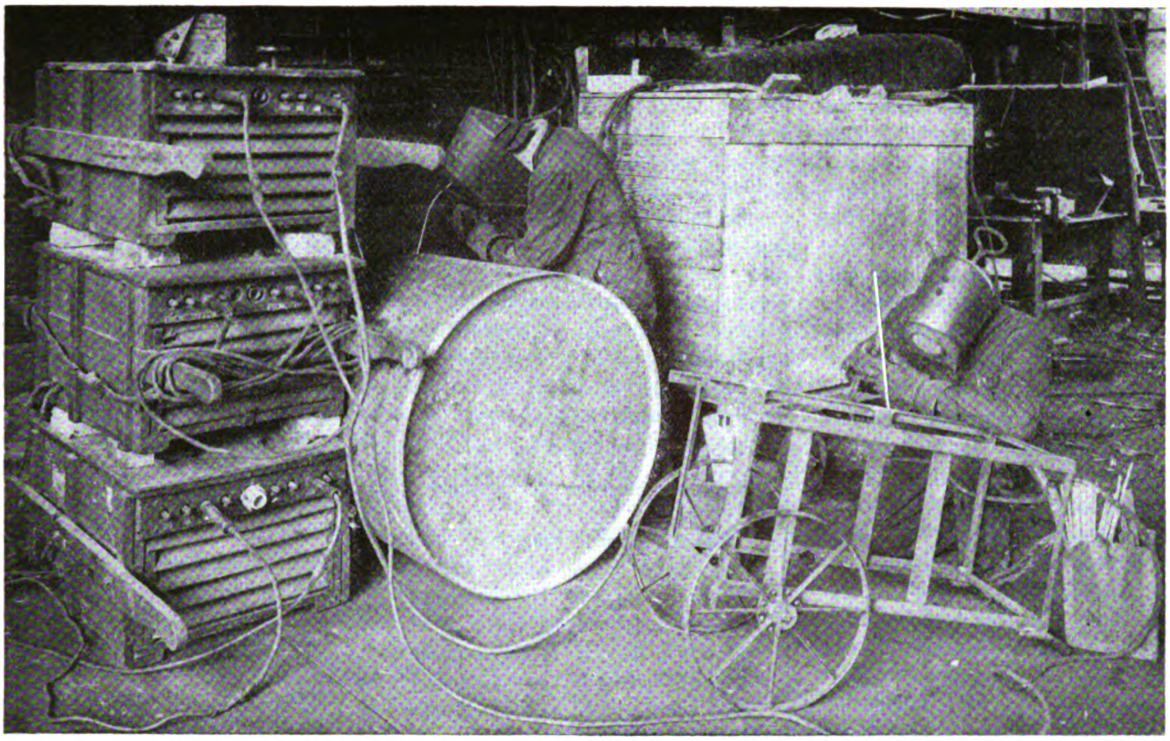
In connection with the control a door switch is of importance and, for convenience, a push-button station is usually employed to start and stop the oven heating operation.

There is nothing particularly complicated about electric ovens, but it is important to remember that they must be especially designed for the use of electric heat, as fuel-fired oven construction is often very unsuitable in this connection. Most of the features of design depends, however, upon empirical data, because so little is known of convection.

Fig. 6—Contactor panelboard controlling the various sections of a large oven installation.

The current to the heaters is controlled by the thermostat, acting through relays and main line contactors.





This is the type of welding transformer referred to in the accompanying article. Courtesy the Electric Arc Cutting and Welding Co., Newark, N. J.

How we make use of

Electric Arc Welding

to keep equipment in service

By J. S. MURRAY
Chief Electrician,
Follansbee Brothers Co.,
Toronto, Ohio

WELDING has become a practical necessity in steel mill operation, where almost every piece of equipment is subjected to severe service with the resultant heavy wear and breakage that accompany such service.

When moving parts of a piece of equipment have even a small amount of play or backlash, the severity of a shock or reversing load causes wear which increases in rapidity and seriousness with the resultant increase in play. Although gears, pinions, and other sliding or rolling parts in modern steel mill equipment do not have the play which was a characteristic feature of the old-time equipment, nevertheless there is usually some. The abrasive conditions under which much of the equipment must operate also effects the wear.

Breakage is high because equipment is powered high to permit it to handle the heavy loads of operation and so, whenever anything interferes to cause sudden stoppage, something breaks. It requires a tremendous shock to break a 15-in. or 16-in. shaft, although this sometimes happens.

Before the perfection of welding and its application to steel mill operation, the loss from breakage and wear was a very serious problem because there was practically no salvage, except as scrap, from the broken and worn parts. Welding, as carried on at the Toronto plant of Follansbee Brothers Co., consists of repairing broken parts, building up worn surfaces, fabricating by cutting, fitting and welding, and cutting out and removing worn and other parts which it is desired to change or discard. Cutting is, in reality, the opposite of welding, but it is usually, and in this discussion will be, considered as a part of the welding work involved in the maintenance of equipment.

"Large worn gears are removed and the teeth built up with the electric welding unit. The gear is then taken to the machine shop and the teeth recut. The entire rebuilding job, including the welding and cutting of the teeth, costs about $65, whereas a new gear would cost approximately $225. Gears with renewed teeth last practically as long as new gears, and the building-up process can be continued indefinitely."

Before going further, it may be well to describe briefly the type of activities at our Toronto plant. This plant consists of open hearth furnaces, hydraulic presses for forging the ingots into bars, a bar mill, sheet mills, annealing furnaces, power house, coal mine, and the other auxiliary and necessary adjuncts to plant operation. A feature of this

plant, which is unusual, is that the ingots are reduced by forging under the hydraulic press instead of by a blooming mill, and rolled in a bar mill. The product of the mill is full-finished steel sheets which are used in automobile bodies, steel furniture, and many other varieties of finished product.

The Electrical Department has supervision over about 1,000 motors, rating from 2,000 hp. down to fractional-horsepower units. In addition, there are 27 cranes, the charging machines, forging manipulators, and coal mine machinery, as well as the distribution system to look after. This last division requires comparatively little welding, however, except in the construction of special shapes for mounting some of the equipment, and in the bonding of rails for the cranes and mine locomotives.

At this plant the repairs are divided between the Mechanical and Electrical Departments. The Electrical Department makes all repairs of either electrical or mechanical nature, connected with electrical equipment, or equipment which, in the nature of its operation, is primarily electrical, such as cranes, the charging machines, forging manipulators and other similar equipment. All repairs of any nature are made on this equipment, in addition to all purely electrical repairs. This includes repairs to bearings, gears, pinions, shafts, and so on.

The Mechanical Department looks after the remainder of the repairs to the mill, open hearth and other production equipment in the plant. Incidentally, a large amount of the repairs which the Electrical Department makes are in reality of a mechanical, rather than electrical nature.

The electric welder does work for both the Electrical and Mechanical Departments, and is kept busy most all of the time. Some work is, of course, of emergency nature and must be handled immediately. There is a large amount of work, however, which is placed in the welding room to be repaired or built up as opportunity affords. This material, after repairing, is placed in stock and issued out at the first call. For our electric welding we use a Type CW, 12-kw., 350-amp., 220-volt, single-phase, portable welding transformer manufactured by the Electric Arc Cutting and Welding Co., Newark, N. J.

In addition, both departments have acetylene welding and cutting outfits. Torch work for the Electrical Department consists usually of cutting, although the torch is also used on much of the light welding work and for brazing and non-ferrous metal work.

Use of the acetylene torch is one of the quickest methods for removing structural work of any nature and for cutting any other metal work, particularly where it is not desired to reuse it. Frequently, parts are badly worn or are not to be used again, and so it is more economical to remove and replace them than to try to weld or build them up. A man with a torch can cut away metal much more quickly than it can be torn down by disassembling.

"Guides on the bar mill rolls are also built up in place in two or three hours, whereas it would take practically a day to remove them. This is a big saving in labor, as well as in the cost of new parts for replacement. The decrease in delays to production is, however, one of the most important considerations in steel mill operation, because of the importance of each piece of equipment in the production routine. Equipment that is idle for repairs is not making steel."

Cutting or fitting on the job, and to some extent in the shop, is practically all done by means of the acetylene torch. The Electrical Department naturally does not have as much of this cutting and fitting as does the Mechanical Department with its work around the open hearth furnaces, annealing and sheet furnaces and duct and pipe work. However, we keep the Oxweld gas torch busy cutting and on some welding, in addition to the work handled by the electric welding unit.

It is difficult to list or describe the multitude of welding jobs which go through the shop as a regular part of the daily routine. They vary from jobs weighing a ton or more to light sheet metal. However, I will try to enumerate a few of the things that are done in this plant. In doing this I will first take up the use of the electric welder. All steel filling is done by the electric welding unit.

In motor maintenance the wear on keyways, particularly on cranes, is a very big item. These keyways are filled in and recut and the entire shaft salvaged at a very low cost. Such a repair requires very little more work than would be necessary to press out the old shaft and insert a new one. Bores and keyways in track wheels, brake wheels and so on, are welded and machined in a similar manner.

At the present time we do not build up motor shafts that are worn at the bearings. When such shafts become worn to a certain point, they are replaced with new shafts.

Heat-treated, tool-steel pinions are used on all crane motors and in some other places where the service is exceptionally severe and the gears are exposed to large amounts of abrasive material.

In the case of large steel gears, such as on the internal ring gear on the forging manipulators and on the charging machines, the swinging of the trolleys results in heavy wear on the teeth over a portion of the circumference. These worn gears are removed and the teeth built up with the electric welding unit. The gear is then taken to the machine shop and the teeth recut. The entire rebuilding job, including the welding and cutting of the teeth, costs about $65, whereas a new gear would cost approximately $225. This cost does not include the labor of removing the gear or replacing it, because that would be the same whether a new or salvaged gear were used. Gears with renewed teeth last practically as long as new gears and the building-up process can be continued indefinitely.

When a tooth of a gear is broken it is built up and recut in the same manner. It would be difficult to make an estimate of the amount saved by rebuilding teeth in gears alone, but I may say that this is one of the largest single types of work that we have to do.

Frequently it is possible to use the electric welding unit to build up a worn surface on a part which otherwise would be scrapped. For example, the head on the ram of the charging machine can be built up by the electric welder in about 10 hr. The cost of welding a new ram is between $300 and $400. In other cases welding can be done without removing the part from service.

Guides on the bar mill rolls are also built up in place in two or three hours, whereas it would take practically a day to remove them. This is a big saving in labor as well as

in the cost of a new part for replacement. The decrease in delays to production, however, is one of the most important considerations in steel mill operation, because of the importance of each piece of equipment in the production routine. Equipment that is idle for repairs is not making steel. Also, when interruptions last for a considerable length of time it is sometimes necessary to practically close down a section of the plant, which is very expensive.

Another building-up job which is of especial importance is the filling out of the square ends of the roll spindles, wobblers, and coupling boxes. Such repairs represent one of the biggest items of saving of any made in the plant. In this instance the entire cost of repair is a small item compared with the cost of a new roll spindle.

In addition to the rebuilding of worn surfaces, the electric welding unit is used to unite broken parts of steel and most iron castings. To make a weld it is necessary to V out the material at the break so that the welder can build up from the bottom. In our plant this V-notch is cut with the acetylene torch on practically all jobs of considerable depth or diameter. The two parts are then mounted on horses and aligned in the shop and the metal is built in, beginning at the center. After depositing some metal the part is turned and a corresponding amount deposited on the opposite side to assist in maintaining alignment and to equalize any strains.

Such a weld is, we believe, as strong or stronger than the original.

When filling a large V the welder must be careful to deposit clear, solid metal without blowholes and make sure that each layer makes a firm bond with that previously deposited.

One interesting welding job was on a broken peel on an ingot charging crane. This was built up in a comparatively short time and did not require any machining to finish it. This peel was made of cast steel and was about 8 in. in diameter, with a cored center. A large bolt was placed in this cored opening to hold the casting straight. The welding metal was then deposited in the V-notch. The repair was made without dismantling in about 4 hr. A new casting would have cost approximately $200, so we were able to make a considerable saving.

During cold weather the cast-iron hydraulic cylinders on the transfer tables sometimes freeze. When this happens the cracks are chipped out and the holes filled in with the electric welder.

Gear guards for cranes are welded either electrically or by the Oxweld torch, whichever happens to be the most convenient. The latter is used, however, for cutting and fitting metal for the guards.

All brazing or welding of nonferrous metals is done with the Oxweld torch. It is also used for filling in blowholes or building up broken teeth in bronze gears. In one instance, a weld was made in the impeller of one of our centrifugal pumps, and on several occasions stuffing boxes have been built up and then rebored.

In addition to its use for cutting metal in reclamation work, the acetylene torch is also employed in cutting up large pieces of steel into scrap. For example, after annealing boxes have become warped out of shape and can no longer be used, they are cut up with a Prest-O-Lite torch into pieces small enough to go into the open hearth.

In addition to the arc welding outfit which has been described, we also use a resistance-type welder for welding track bonds in the coal mine, which is a part of our property. Also, the rails which are used as conductors in the mill are bonded.

New jobs of different types are coming up every day and so we are constantly being called upon to do things which we had never thought of doing before. The application of welding to maintenance work grows in the plant as the men become familiar with the work and with the possibilities of their equipment. Welding is of especial importance in the steel mill because it affords a means of reclaiming economically many parts which would otherwise have to be scrapped.

Thermit welds are also becoming a very important addition to this class of work. We have had some 16-in. × 18-in. shafts welded in this manner by outside crews.

Elimination of Hazards in the Operation of Overhead Cranes

By C. E. SANKEY
Safety Engineer, National Tube Co., Ellwood City, Pa.

WHEN the word "hazard" presents itself to me, it is immediately followed by the word "overcome." It is the work of the safety man in any plant to overcome any condition that may cause accident or injury to an employee. My experience so far has led me to believe that the only way to overcome any so-called hazard is to educate the men not only to be cautious, but to be alert and awake to the dangers of the work they are doing and the machinery they are handling.

This paper* will devote special attention to the hazards incidental to the operation of cranes. All cranes are built according to certain code requirements, are technically right, and have been so proven by the tests called for in the specifications. The design is made to meet the needs of the department in which they are installed. The placing of lights, so as not to cast shadows on work being done, and clearance, because there should be ample floor space in the bay to enable the operator to see the load he is to lift as well as the men who are working with it, are two questions that should be given special attention because both are important from the safety viewpoint. As a man's environment influences his work to a great extent, it is essential that the crane cab be light and properly ventilated. Accidents have been caused by cranemen being drowsy, due to poor ventilation.

After a crane has been installed and tested, it is the duty of the Electrical Department to see that the brakes, limit switches, overload, and other safety devices are kept properly adjusted, and that the cranemen understand the mechanism sufficiently to take proper care of it, and to recognize immediately any condition that may lead to disaster. This training can be done in only one way, and that is by precept and example.

A man who is being considered for the position of craneman, and preference should be given to men who

*Note: From a paper read before the Erie Regional Conference, National Safety Council, May 17, 1927, at Erie, Pa.

have been employed in the department for some time and know working conditions and the class of material to be handled, should have a physical examination with special attention to sight and hearing.

Cranemen should be relieved of any responsibility arising from disputes. These should be settled by the foreman because a craneman who harbors resentment and anger toward those with whom he is working may be tempted to retaliate, if he thinks he has been unjustly treated, and the result may prove disastrous. In addition to being given a copy of "Rules of Operation," as outlined by the State Safety Code, the craneman should be told that he must use a ladder or steps for his entrance to the crane; climbing up or sliding down girders is a dangerous practice. In addition, the following rules and points should be clearly explained:

He is not permitted to take into his crane cab any contrivance on which to sit, as the company would have provided a stool if it had not been proven to be impossible for a craneman to obtain a full view of those underneath him while he is sitting. Also, he is not allowed to entertain his friends in his cab, nor is he to carry papers or magazines to his crane to be tempted to read, as his mind must be kept clear.

The craneman is held responsible for the working condition of his crane, which will necessitate a daily inspection with a weekly report on a form provided for this purpose. This report, a copy of which is reproduced here, is handed to the Superintendent at the end of the week for his approval, and then forwarded to the Safety Department.

The first duty of the craneman on entering the cab, should be to see that the controllers are in the off position, and then signal by ringing his bell and waiting a minute or two to determine whether someone may be working on the crane without having locked the switch.

Much of the responsibility in connection with the operation of a crane depends upon the judgment of the craneman, but he should have some definite rules and policies for his guidance. For example, he must refuse to move a load that he believes is too much of a lift; under no circumstances is he to do so without authority from his foreman. Also, he must never carry loads over employees. In case a man working on a runway does not step out of the way after the first alarm is given, the craneman should give a second alarm; if the man still refuses to move, the craneman may pass over him, but a second offense must be reported to the man's foreman.

Under no circumstances is the crane operator to take signals from two different sources when lifting a load that requires special maneuvering. He must wait until he has been signaled by the proper authority to lift and move. Another rule is that when lifting buckets or other vessels, at no time should two be raised at once on one chain, or even on two chains or cables.

The craneman must be made to realize at all times the responsibility of his position; that he is to be alone 20 ft. above his fellow workmen from 4 to 5 hr. at a stretch, with no one to consult; that he must learn to depend upon his own wits and common sense; that any deviation from the safety rules may lead to an accident which may prove fatal; and, that continual vigilance must be exercised.

The floormen must also be given instructions as to their part in protecting their fellow workmen, and have pointed out to them the dangers in connection with crane operation.

Although the human element, the operator, must be given especial attention and supervision, and held at least partially responsible for the condition of auxiliary equipment, such as chains and cables, it is well to employ an inspector for this work as a check and as a definite insurance that the inspection is carefully made. In addition, prizes are sometimes given to those who may find defective links that have escaped his notice. Where this inspection and prize check-up system has been in use it has proven to be an important incentive for alertness on the part of those handling chains and has helped to prevent many accidents.

A weekly inspection report, such as this, is made out for each crane.

C-30

CRANEMAN'S REPORT

CONDITION OF CRANE FOR WEEK ENDING .... CRANE No. .... DEPT. ....

CONDITION OF	REMARKS	APPROVED BY FOREMAN	ORDER No FOR REPAIRS
CHAINS, CABLES AND HOOKS			
BRAKES			
GEARS			
END TRUCKS			
TROLLEY FRAME			
CRANE TRACKS			
TROLLEY TRACKS			
LIGHTS			
BEARINGS			
LIMIT SWITCH			
MOTOR			
CONTROLLERS			
WARNING DEVICES			
FIRE EXTINGUISHERS			
MAGNET CABLES AND PLUGS			

IS CRANE CLEAN AND FREE FROM FALLING MATERIAL ....

LAST INSPECTION WAS MADE BY .... ON .... 192....

DATE OF REPORT .... 192 .... OPERATOR

DATE OF APPROVAL .... 192 .... FOREMAN

.... SUPT.

CRANEMAN MUST HAND THIS REPORT TO FOREMAN.
FOREMAN SHOULD NOTIFY CRANEMAN OF APPROVAL OR DISAPPROVAL OF SUGGESTED REPAIRS.
SUPERINTENDENT WILL FORWARD THIS REPORT TO SAFETY DEPT

Attend the *Iron and Steel Convention* by Proxy, if you cannot be there in person

NOT all of the men who are responsible for operation of the electrical equipment in our iron and steel mills can attend the big convention of the Association of Iron and Steel Electrical Engineers to be held at Pittsburgh, June 13 to 18. It is expected, however, as heretofore when these conventions have been held in the Iron City, that a good representation from the foremost plants of the country will be on hand to listen to the papers that have been prepared and take part in the discussions from the floor.

IRON and steel men never seem to be bashful in telling what they have on their minds after the papers are read at a meeting and discussions are requested from those present. For this reason the discussions give a man things to ponder over and are far from the "Yes, sir, I agree" comment that fails to bring out any of the points that might be added to a paper when there is full and free discussion.

THE program this year has been carefully prepared and the topics cover the larger problems of operation common to most plants, so that every suggestion will deserve careful study from the standpoint of adopting all or at least that part which can be used with benefit. Even though the benefits are not apparent at once, the suggestions will come from such important plants that they deserve trial and experimentation before being passed by as good for somebody other than yourself.

FOR those who have to stay at home, the members of our editorial staff and I will attend and report in detail those things that come up in which you will be interested. In other words, you will have decidedly interested representatives at this convention so that when you get our July issue you can sit down by yourself and go into convention alone with much profit if you follow this suggestion:

YOU will find in referring to the papers and the discussions on these that the names of the individuals, their positions, plant connections, and addresses will be given. When reading over these discussions, mark the sections of interest along your line of work. Then write your comments on the points brought out, from your experience in your own plant, and send them to INDUSTRIAL ENGINEER for publication. Such comments when published always draw remarks from other men, so that the benefits of this interchange of experience will be extended to many more men than could have found it possible to attend the convention.

WE MENTION this so that when you get our report number covering the convention you will not just read it and lay it aside. If you are a steel mill man or an operator in any other plant and are interested in the topics reported, make it a point to add your comments on the subject you are most interested in, and send them in as soon as possible after our July issue reaches you. In case you cannot write your comments then, they will be welcome at any time, if they come from the heart and give information based on experience with the improvements that new methods and processes have brought to the iron and steel industry.

Practical Pete

P.S. IF YOU are going to be at the convention, stop at Booth 131 and pay us a visit; let's get acquainted P. P.

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of
Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, *Editor*

Save Money by Saving Time

THERE is oftentimes a strong tendency to consider the adoption of a new method or tool solely on the basis of the easily-proved saving that it will make. The desire to save as much money as possible by cutting operating and maintenance costs is entirely justifiable. One should not, however, overlook the fact that indirect savings and incidental advantages may be of more real importance than savings that can easily be expressed in terms of the dollar sign.

In his article on the use of arc welding, page 281, J. S. Murray expresses in the following words a viewpoint that can well serve as a sound basis for judging the worth of any method or equipment applicable to maintenance work:

"This is a big saving in labor, as well as in the cost of a new part for replacement. The decrease in delays to production is, however, one of the most important considerations in steel mill operation, because of the importance of each piece of equipment in the production routine. Equipment that is idle for repairs is not making steel."

Idle equipment represents idle invested capital and productive capacity. This fact should be sufficient justification for the purchase or use of anything that will help to prevent breakdowns, or save time in getting equipment back into service in the event of failure. The question of how much money it will save in so doing, as compared with other methods, is of secondary importance.

Putting Method into Maintenance

MEN supervising maintenance in industrial plants are well aware of the frequency of misunderstandings in connection with telephoned requests for emergency assistance. The urgency of the situation may well justify a hurried telephone call, but it is well to remember that too much haste is likely to result in waste of both time and effort.

Two of the most common causes of misunderstanding are failure to learn just where the trouble is, and inadequate information on what is to be done. When a foreman calls in and merely leaves word to "come over and fix Bill's machine," there is a possibility of the repairman going to the wrong Bill. These mistakes waste valuable time, and the Maintenance Department is always held responsible.

Where shops are laid out in bays and sections which are identified by numbers or letters, the plan of requiring that these identification marks be given will save trouble. In any case the department name or number, floor number, and other identifying marks can be required.

Inadequate information as to the nature of the trouble is probably the greatest source of lost time in making repairs. For this reason, it is the rule in one plant not to send a repairman until as much information as possible is obtained over the telephone. It is said that in more than 90 per cent of the cases he is able to take enough tools and supplies to make the repairs needed. Before this plan was inaugurated he had to make two or more trips about 90 per cent of the time.

It is advisable, of course, to avoid undue complication of routine and procedure, but any plan that will help to organize maintenance work on a more efficient basis is well worth serious consideration.

The World Has Diagnosed Its Economic Ills

A FEW days ago an intrepid young aviator slipped a couple of sandwiches into his pocket, climbed aboard his airplane, and in less than 36 hours was asleep in Paris.

Any American business man can now call up and talk to a customer in England, say, with little more ceremony than would be involved in calling up his own home, or a friend down the street.

With the rapid annihilation of distance as an obstacle to travel or communication, there has grown up a marvelous structure of international business. Mighty as this structure is, it is, nevertheless, so delicately balanced that comparatively small changes in conditions may have far-reaching effects. European nations are facing many serious problems and, whether we will or no, the successful solution of these problems is certain to mean much to our own prosperity, as well as theirs.

It was fitting, therefore, that the International Economic Conference should have been called under the auspices of the League of Nations to consider means of hastening the revival of prosperity in Europe. This conference adjourned a few days ago. Reports from E. J. Mehren, one of the vice-presidents of the McGraw-Hill Publishing Company who has been covering the conference for the McGraw-Hill publications, indicates a goodly measure of accomplishment.

Among other things, the delegates recommended the removal of hampering trade barriers, declared the value of an efficient industrial organization as an aid to economic recovery, considered the function of international industrial pools, and urged international statistics that should result in more intelligent management for industry and agriculture.

Of special importance was the declaration that Labor should co-operate in the reconstruction program. How much more rapid would our own scientific management movement have been if Labor had always been party to it! Europe, about to begin an intensive study and application of all devices for reducing costs, has started in the right way by getting the help of the workers.

Accord was established on many important points, which is a necessary step for effective action. Probably the most notable commerce recommendation is tariff stabilization, making long-term contracts possible. Highly commendatory are the recommendations for the collection of world statistics on raw materials and agricultural products, and studies of basic materials in which a world shortage is most feared. Intelligent world economy in industrial and agricultural production and marketing is not possible without such figures and studies.

Aside from these definite recommendations and conclusions, much good has been done. The world now has a clear understanding of its economic ills and knows what the ablest specialists think are the remedies therefor: thus a basis for action has been laid. Although quick results must not be expected, as the problems are large and complicated, this conference would seem to have justified its being.

Special Belts Are Solving the Problem of the Narrow Pulley

ONE of the most common methods of meeting the demands for increased production is to increase the speed of the machine and at the same time take heavier cuts with tools that have been designed to stand the heavier load. Often after these tools are installed it is discovered that they cannot be operated at the expected capacity because the pulley width will not permit the use of the wider belt which is necessary.

Oftentimes an attempt to use an ordinary double belt does not meet with much better success because the diameter of the pulley is so small that the heavier and stiffer belt does not bend so readily and give the necessary adhesion to the small pulley. Also, in order to get the increased speed, the diameter of the driving pulley is usually increased, which decreases the arc of contact on the machine pulley and makes the drive more difficult for the heavier belt.

Belt manufacturers are meeting this problem by providing special belts which are heavier and also more flexible than those made from leather of ordinary tannage. Belt users are finding these especially adaptable where demands for an increase in power transmitted are limited by pulley sizes or the arc of contact obtainable.

Operating men who are having trouble with such drives may find it to their advantage to ask the belt manufacturers for their recommendations.

Why Fan Static Should Be Accurately Determined

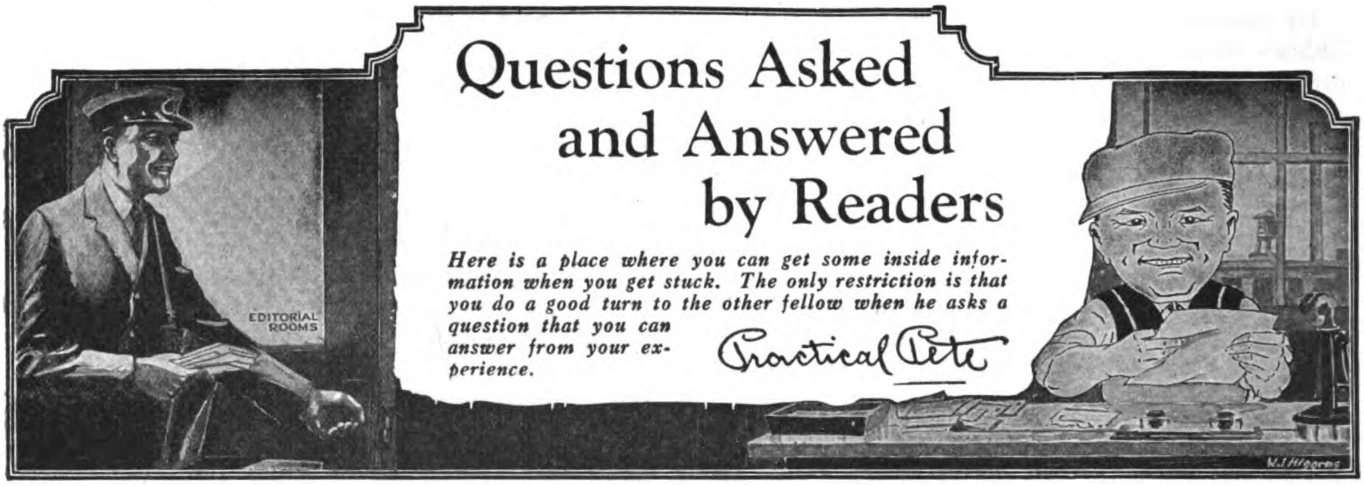
BLOWER and exhaust fans have been used for so long that certain rule-of-thumb practices have been adopted for selecting the sizes of motors required. Most of these rules are the seat of trouble at some time. This is particularly true of the one by which motor horsepower is specified as 50 per cent more than the brake horsepower of the fan or blower. In many cases this results in an induction motor operating at low power factor and reduced efficiency when the fan is properly adapted to its duct system.

The bugbear in these rules of guess is the static pressure under which a fan may be assumed to operate. Static pressure is the compressive pressure existing in air or any liquid and is a measure of its potential energy. It is usually measured in inches of water. It is the means of providing flow of air and maintaining it against the friction between the moving air and the duct surface. When a motor rating in horsepower is selected for a definite static pressure and fan wheel speed and the fan has a pressure characteristic or curve that slopes downward on both sides of the 100 per cent capacity point, the operation of such a fan at a lower static pressure than assumed, without a reduction in speed, increases the volume of output and calls for a marked increase in the horsepower of the motor.

When the rated motor horsepower is close to the brake horsepower of the fan, the overloading of the motor when direct-connected may be enough to burn out the windings. In any case it will cause overload relays on switches to trip frequently and cut the fan out of service, with the result that some operator may find fault with the relay settings and put them beyond the point of safe protection for the motor.

In the case of a belted fan unit there is much more leeway in correcting a bad guess in static pressure. The easiest method is to increase the size of the fan pulley, so that the volume of air from the fan is brought down to that corresponding to the actual static pressure. This requires a knowledge of the fan characteristics and efficiency, and a check on the static pressure with a pitot tube. The use of such a device in correcting motor overloading is only a relief for the situation. The correct procedure is to calculate the static pressure carefully when the fan installation is laid out, so that both fan and motor will be suited to the job at hand. A little time spent then may prevent much serious trouble later.

Guesswork in connection with blower and exhaust fans of the housed type, either as to capacity or motor horspower required, is a very troublesome tool, even when used by those who have had considerable experience in ventilation work.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience. Practical Pete

QUESTIONS

Who Can Answer These?

Loading Synchronous Motor to Improve Plant Power Factor

The total load on our plant is 566 kw., at 75 per cent lagging power factor when a three-phase, 440-volt, synchronous motor is pulling 105 amp., from the line, with the excitation adjusted for 90 per cent leading power factor. Will some reader tell me what the plant power factor will be if the synchronous motor load is increased to 300 amp., and the excitation adjusted for 90 per cent leading power factor at this load?
Cleveland, Ohio. B. E.

Parallel Operation of Alternators

We are considering the operation of a high-speed, steam-turbine-driven, 500-kva. alternator in parallel with a 3,000-kva. alternator driven by a low-speed, hydraulic turbine. Will readers kindly tell me what difficulties, if any, will be experienced in synchronizing and cutting the alternators in on the lines? During parallel operation under different load conditions, what troubles are we likely to encounter? Also, will any special governing device be required? W. A. P.
Smooth Rock Falls, Ont., Can.

Can Formation of White Incrustation on Brick Be Prevented?

Our main office building is built of pressed red brick, most of which is covered with a white, salt-like incrustation that is very unsightly. Part of this can be brushed off, but it soon forms again. We do not want to paint the building if it can be avoided and I should like to know if there is any treatment that can be applied to the bricks that will prevent the formation of this white coating.
Chicago, Ill. R. P.

Maximum Economical Size of Motor for Group Drives

We have a number of group drives operating screw machines, lathes, and so on, the driving motors ranging between 20 and 40 hp. Installation of new machines will make it necessary to replace two 40-hp. induction motors with larger ones, or to split these two drives into smaller groups. I understand that some plants will not use a motor in excess of 35-hp. rating on a group drive, the group being split up when the power required exceeds this figure. I wish that some readers would let me know what their policy is on this point, and tell me how they determine the maximum economical size of motors for group drives. That is, when should a group drive be split up instead of installing a larger motor to take care of increased power demand?
Moline, Ill. W. B.

Scott Connection for Multiple-Circuit Motors

I will have to reconnect a number of four-, eight- and ten-pole, two phase, motors for three-phase operation and wish to use the Scott connection, but can find directions and diagrams only for six-pole, series-connected motors. Will some reader tell me how to use the Scott connection on motors having two, three and four circuits?
Philadelphia, Pa. R. I. G.

Interpretation of Graphic Meter Record

I have run several tests on a gear-driven duplex plunger pump and should like to know why the graphic wattmeter records are as shown below instead of being a straight line, thus indicating a steady power input. The cranks on opposite

sides of the gear are set at 90 deg. Will readers please tell me whether such a chart is normal, or is due to defects in the meter, or in the pump or motor. Also, can graphic meter records be used to detect or locate pump troubles?
Detroit, Mich. S. B.

What Causes Spotting on This Commutator?

We are having trouble with a 200-kw., Type HCC G.E. rotary converter which was rewound about a year ago. This machine ran perfectly until three months ago, when it began sparking at the brushes, and black spots formed in three places equally distant around the commutator. The mica is not high because we have stoned this commutator three times in the last three months, and in addition have checked the winding for open circuits. Will some reader kindly suggest a remedy for this trouble?
Logan, W. Va. F. H.

ANSWERS

Received to Questions Asked

Cause of Short Life of Lamps

In our knitting department there are many belts, every other one being crossed. The wiring for the lighting system in this department is enclosed in conduit, which is grounded. I am using the No. 622 Holophane lighting unit, which is a glass reflector. Although I have used both 110- and 115-volt, A 23 and PS 25 lamps, respectively, on a circuit that indicates a constant voltage of 106 volts on a recording voltmeter, the lamps in these units last only about 100 hr. I shall appreciate any information that readers can give me as to why our lamps have such a short life, and how I can remedy this condition.
Newton, Mass. D. C. S.

IN REGARD to the question by D. C. S., if these lamps are near moving belts, the static electricity induced by the belts will cause trouble with lamps.

I once had a similar experience, in which the lamps were short lived due to static electricity on high-voltage busbar structures. It was found that by inclosing the bulbs in an ordinary wire lamp guard and grounding the guard to the conduit, the life of the lamps was increased considerably.

While I cannot state positively that this suggestion will remedy D. C. S.'s trouble, I believe it would pay to try it out by purchasing a few wire lamp guards. After inclosing the lamps that are giving trouble, ground the guards to the conduit. If this method is tried out, I shall like very much to know the results obtained.
Dallas, Texas. A. L. Tuffly.

IN ANSWER to the question by D. C. S., his trouble appears to be caused by vibration. If the recording voltmeter is correct, the A 23 and P. S. 25-watt lamps should give a normal life, provided there is no other trouble.

It might be advisable to obtain the old Type P. S. 25-watt lamps as they stood considerable vibration. The P. 19 mill-type lamp would probably work better in this case if they were

made in a 100-watt size, but I do not believe that they are made larger than 50 watts.

Trouble from vibration may also be lessened by using a short piece of reinforced cord between the outlets and sockets. J. A. BANTAU.

Los Angeles, Cal.

IN ANSWER to the question by D.C.S., our experience with such troubles has proved that they can ordinarily be overcome by using either an Edison Mazda B mill-type lamp, which is obtainable only in the 110-volt, 50-watt size, or the type of lamp that is generally used by street railway companies. These lamps are used five in series on a 550-volt circuit and are rated at 95 watts. In case these lamps are too small for D.C.S.'s use, it will be necessary to either devise or purchase some sort of spring to suspend the lighting units in order to absorb the vibration, which I believe is responsible for the short life of the lamps.

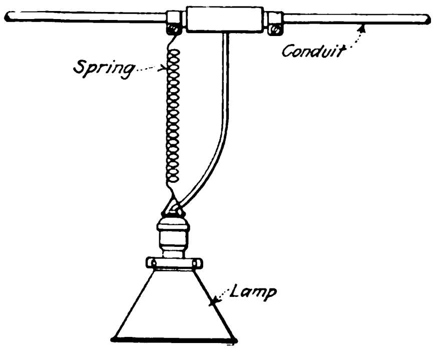
The Martindale Electric Co., Cleveland, Ohio, can furnish what are known as cushion hooks to cure such troubles. These hooks are for use in suspending Mazda and Type C lighting units in connection with supports and hangers. The cushion hook is made of heavy stamped steel formed about a spiral spring from which the fixture hangs, the hook serving as a combination suspension and shock absorber, thus protecting the lamp from jars and vibration which would likely result in damage to the filament.

District Line Supt., H. J. ACHEE.
Southwestern Light & Power Co.,
Elk City, Okla.

ABSENCE of definite information as to the location of D.C.S.'s lamps as regards their proximity to belts, and whether they are suspended so as to eliminate vibration or not, makes the solving of the problem rather difficult. No definite information is given as to whether the trouble is confined to one particular area, or whether it is spread out over an area that includes all the lamps. However, I will enumerate some of the troubles I have encountered with lamps and the manner in which the trouble was corrected.

D.C.S. states that the wiring is enclosed in conduit and I assume from this that the sockets are suspended

Suspending a lamp from a long spiral spring will minimize the effects of vibration.



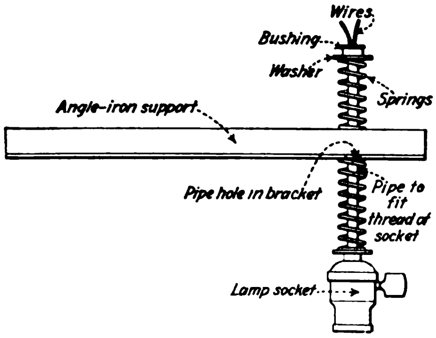
from drop cords. In this case little trouble should be experienced from vibration. However, in cases where the floor above is occupied by machinery that causes considerable vibration, trouble may be experienced. In cases where trouble of this nature is encountered the best remedy is to suspend the sockets on a spring attached to the ceiling, as shown in the accompanying diagram.

There is a remote possibility that static from the belts in the knitting department is causing the trouble. I have in mind one case where static from a belt seemed to affect the filaments to such an extent that the lamps burned out after a few hours' use. To stop the trouble from this source a grounded wire was run parallel with the offending belt.

ARCHIE L. FORGER.

Chief Electrician,
The G. A. Head Electric Co.,
Laconia, N. H.

REFERRING to the question by D. C. S., I presume he has examined the lamps for clues to the cause of the trouble, although he does not mention them.



This shows how a lamp may be supported to eliminate filament breakage due to vibration.

Blackened lamps, with an occasional white opaque one, are signs of over voltage, whereas broken filaments show that vibration is causing the trouble. From his description I believe that vibration is causing the trouble.

I recently saw in one of the engineering magazines a diagram of a spring hanger for supporting lamps, similar to the one shown in the accompanying illustration. Another spring lamp similar to the one that I have just described is illustrated in an article, by O. C. Callow, entitled "Cutting Costs of Operating and Maintaining Lighting Systems" on page 67 of the February issue of INDUSTRIAL ENGINEER. H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

ANSWERING D.C.S.'s question, I had a similar experience with lamps that were short-lived. These lamps were operated among a large number of endless glued belts that ran over wooden pulleys. The short lamp life was due to the static electricity generated by the belts. The lamps in this case lasted from 48 to 96 hr. which is not very long.

The trouble was remedied by installing a copper wire comb, made of No. 18 and No. 8 wires, close to the belt. This arrangement eliminated the trouble from short lamp life.

If glass reflectors are used in D.C.S.'s installation, I would expect more trouble with the lamps than if metal reflectors were used and grounded.

One way of determining whether static is causing the trouble is to make a turn of No. 18 wire around the glass lamp globe and then fasten one end of this wire to the conduit at a spot that has been scraped clean just above the condulet or socket.

Static may also be produced by the knitting machines. In this case ground the machines, and then run a copper wire close to where the threads pass from the spools to the machines. I shall be interested to learn how D.C.S. eventually overcomes his lamp trouble.

WM. KOEPERNIK.

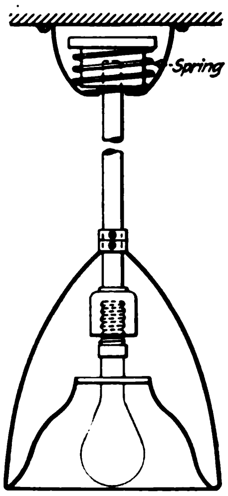
Foreman of Electricians,
The Larkin Co., Inc.,
Buffalo, N. Y.

REFERRING to D.C.S.'s question, the information furnished indicates that he suspects that the trouble is due either to overvoltage or static. If he has tested the voltage and found that it is suitable for the lamp, we can eliminate that consideration.

The disturbances caused by static discharges are very similar to those from lightning discharges. Although D.C.S. could test for static discharge and note the effect on the life of the lamps, I doubt if this test will lead him to a solution of his problem.

The short life of incandescent lamps in industrial plants carrying on certain operations in buildings of certain types of construction is a well-known phenomenon. It is due entirely to vibratory stresses set up in the lamps by the operation of the machines, which become aggravated when the natural period of the vibration of the filament happens to be an exact multiple of the period of vibration set up in the building. As a rule lamps do not go out while burning because the filaments are soft and pliable, but break while they are not burning.

This shows the construction of a lighting fixture designed to eliminate lamp vibration.



The remedy for this trouble is the installation of shock absorbers, such as Type UNJC or Type H, manufactured by Crouse-Hinds Co., on the fixtures. These shock absorbers are inexpensive and easily installed.

I would suggest that D.C.S. equip about ten of his fixtures with shock absorbers similar to the one shown in the illustration and then report the results of this test to INDUSTRIAL ENGINEER for the benefit of other readers. The cost of equipping fixtures with shock absorbers should not exceed $1.50 per fixture. E. OGUR.

Consulting Engineer,
New York, N. Y.

IN REPLY to the question by D. C. S., assuming that the voltage indicated was correct, I would blame the cause of the trouble on vibration. If vibration is causing trouble with the lamps, the use of modern spring fixtures will materially increase their life.

It is possible that the lamps are being periodically crossed with higher voltage leads, for as the lamps he mentions are burning at 84 and 61 per cent efficiency, respectively, this fact would ordinarily indicate that they should last longer.

For mill service it seems to me that I would use a mill-type lamp in place of the present lamps for they are better adapted to such service especially if vibration is decreasing the life of the other type lamps. To increase the lamp efficiency I would recommend raising the lighting-circuit voltage to the normal rating of the lamps. E. J. MORRISSEY.

Chief Electrician,
Western United Gas and Electric Co.,
Aurora, Ill.

What Is Best Kind of Insulation for Semi-Closed Slot Motors?

I shall appreciate it very much if readers will tell me whether it is better practice to use varnished cambric between each coil in a semi-closed slot motor, thereby insulating each coil from its neighbor, or to tape each coil separately and then use insulation only between phases.
Rome, Ga. M. S. C.

REGARDING M.S.C.'s question, the following will describe some methods used to insulate the slot and end sections of partly closed slot motors, the slot sections being considered first:

The first method requires a bent winding cell with lips or three bends, as shown in Fig. 1, the bottom slot being a snug fit for the slot; the overhanging top ends or lips should leave the opening unobstructed.

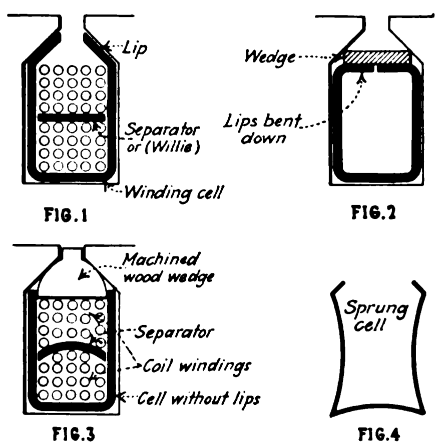
When only one cell is used, it must be a combination slot-insulation material at least 0.023 in. thick. This material has a fishpaper base with treated cloth cemented to it, thus resulting in a cell having good mechanical and dielectric strength. The cells should be at least 3/4 in. longer than the core and the fishpaper placed against the iron.

Next, a fiber separator, which is used between the top and the bottom coil halves, can be 1/32 in. or 1/16 in. thick depending on the slot room. It must be a snug fit width-wise in the slot, not so tight as to cut the cell, but close enough to bind and hold the bottom coil half down. When tamped with a tee drift and mallet, the separator should also be at least 3/4 in. to 1 in. longer than the length of the top coil half. This extra length insulates between the top and bottom layers of coil ends at the point where the clearance is smallest and where the difference of potential is high.

After both coil halves are in, a 1/16-in. fiber wedge, cut wide enough to make a driving fit and long enough to project 1/4 in. on each side of the core, is driven in, the lips being folded over under the wedge, as shown in Fig. 2.

This type of cell prevents the wires from getting between the core and cell at the top and must be used when the slots are well filled, or when the winding is within 1/32 in. of the bottom of the tooth overhang.

Fig. 3 shows the second method, in which a combination slot insulation cell without lips is used, the separator being of the same material and guttered or dished as shown. The wedges are hard wood (maple) and machined to fit the upper slot. It is highly important that the bottom section of the wedge be a snug fit inside the winding cell as shown, and the bottom of the wedge



This shows how coils in semi-closed-slot motors should be insulated.

must be at least 1/32 in. below the top of the winding cell. This last type of cell requires more care in driving the wedges as the wires are likely to get between the cell and the iron.

The first method is the best for general repair use, the only disadvantage being the two extra bends for making the lips. Fig. 4 shows how the cells should be sprung before placing them in the slot. This opens them out and keeps the lips open and the cells stiff. All bends should be made parallel to the grain of the fishpaper.

If a plain paper winding cell is used, an 0.007-in. or 0.010-in. treated cloth cell must be used for both the bottom and top coil halves; that is, two cells are cut and turned over their respective coils and the separator should also be used, as the wires are likely to work up between the folded cells.

There are about four methods of insulating the coil ends, but the first two are for use onlv when the motor is in a clean location, free from metallic dust, grit, and the like.

(1) With this method the coil ends are not taped, but triangular pieces of 0.010-in. treated cloth are put between the coil ends, two thicknesses being used at the point between two pole-phase groups for phase insulations. This is a quick and satisfactory method for motors that are to be used in clean locations.

(2) This method is the same as (1) except that the last coil of each group is taped with one overlapping layer of 0.007-in. cotton tape from cell to cell, and one triangular strip is put between the coils. This is a more positive phase insulation and it is also easier to identify the phase groups.

(3) This method calls for all coil ends to be taped with one layer of 0.007-in. cotton tape, with one strip or triangular piece of treated cloth between the beginning and ending of adjacent phase groups.

(4) This is the same as (3) except that the last coil of each pole-phase group is taped with one layer of 0.010-in. treated cloth tape and one layer of cotton tape.

Method (3) is preferable to the first two, for it is quicker and the triangular strip or butterfly, as it is called, also provides insulation between the top and bottom layers of coil ends, besides helping to mark the phase groups, which helps in connecting. The last two methods should be used for motors operating in dirty places or where metallic dust, oil, grit or the like are present.

All the above windings should be given at least one dip in a good, black plastic baking varnish the number of dips being increased to suit the application.

A good combination for repair shop use and clean applications is to insulate the slots as shown in Fig. 1 and treat the coil ends as described under method (2). For other applications where dirt, oil, metallic dust and other foreign substances, are present, use the method shown in Fig. 1 for the slots and the procedure under method (3) for the ends.

The slot insulation outlined above is satisfactory for 110-, 220- and 440-volt motors, but for 550 volts, treated cloth cells should be used in conjunction with the combination slot insulation. A. C. ROE.

Renewal Parts Engineering Dept.,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

Substitute for Shearing Pins

We have a conveyor line which is driven by a 3-hp. motor through a worm reduction gear. A coupling with a shearing pin is placed between the conveyor and reduction gear for protection when the conveyor becomes clogged, which it frequently does. Some time is required to replace the shearing pin and I wish to eliminate it if I can. Could a clutch be used that would slip and thus absorb the shock when an excessive load comes on, as is the case when the conveyor becomes blocked.
Youngstown, Ohio. J. L. B.

IN REPLY to the question by J.L.B., he does not state whether the pin is to protect the gear or the motor. If it is the latter and the motor is adapted to across-the-line starting, a push-button starter equipped with thermal overload relays will clear the motor from the line before it becomes dangerously hot and allow it to be started up again as soon as the conveyor blockade is cleared and the relay reset.

Control devices, that are adapted for this sort of service are manufactured by the General Electric Co., The Cutler-Hammer Manufacturing Co., Industrial Controller Co., and several others.

Vancouver, B. C. L. E. DUNHAM.

ANSWERING J.L.B.'s question, the simplest way to solve his problem would be to substitute some form of overload electrical protection in place of the protection afforded by the shearing pin. Most likely this shearing pin can be replaced by a stronger one, or the parts in which the pin is inserted can be bolted together so that in the future the overload protection of the conveyor will be at the motor. Obviously, if the conveyor clogs, the motor load will increase and the current rise immediately. The new style of across-the-line starters with temperature overload protection would be admirably suited for such an application. These devices are made by several concerns including the General Electric, Cutler-Hammer, Industrial Controller, Allen-Bradley and other companies.

All of these devices work on the same principle: namely, push-button control operating a magnetic switch. In series with the solenoid of the switch are the contacts of the temperature relay, the coils or operating parts of which are in series with the motor circuit. If the motor current rises above a certain fixed value, the relay opens the circuit. To start the motor again the relays must be set and the start button pushed. This operation will take only a few seconds. Of course, the greater the overload on the motor the quicker the relays will act. This same switch will also protect the motor against no voltage and single phasing.

Although emergency stop buttons can be placed at various points along the conveyor, it is advisable to start the motor from only one point.

I have in mind an installation of a train of conveyors with a crusher located at one end and a sorter at the other, in which all of the motors are equipped with the type of switch previously described. The motors vary in size from 3 to 50 hp. The switches are interlocked by supplying the solenoid coil of the switch controlling the second motor with current from the motor leads of the first motor switch, the third switch coil being supplied from the leads of the second motor, and so on. The coil of the first motor switch is put in series with a number of stop buttons located at various points along the conveyor. Pressing any one of these buttons stops the first motor, thus causing the coil of the second motor switch and all the other coils, to be de-energized, so that all of the motors are stopped immediately.

An overload on the first conveyor motor, such as a blocked belt, will cause the overload relays to open and stop the motor. The crusher switch just below it, being fed from the first conveyor motor lead, will then fall out, stopping this motor. Thus the crusher is automatically prevented from piling a load on the conveyor after it stops.

To sum up the advantages of this method of control J.L.B. can, at slight expense, have at once satisfactory overload protection, low-voltage and single-phase protection and a means of stopping his motors from any desired points.

Manchester, N. H. GARSON A. REESE.

Polarity of Interpoles

I do not thoroughly understand the rule governing the polarity of interpoles and wish someone would explain how it works out under different conditions. For example, on machines that have two interpoles, I have often found them to be of opposite polarity. Was this polarity correct? Can one rule be made to apply to a motor having any given number of main poles and interpoles? I shall be grateful for your help on this question.

Mohiland, Utah. K. W. F.

IN ANSWER to the question by K. W. F., the following rules hold good for checking the polarity in different types of machines: To determine the proper polarity of interpoles for a motor, proceed from pole to pole around the frame, in the direction of armature rotation. Each interpole should have the same polarity as the main pole which just precedes it, as shown in *A* of the illustration. In the case of a generator, each interpole should have a polarity opposite to that of the main pole which just precedes it, as shown in *B*.

Some types of motors and generators have one interpole per main pole, as *A* and *B*, whereas others have one interpole per pair of main poles. Diagrams *C*, *D*, *E* and *F* in the illustration show the polarity of interpoles of two- and four-pole motors with one interpole per main pole and one interpole per pair of main poles, respectively. In *C* the interpoles which are directly across the frame from each other are of opposite polarity, whereas those in *D* and *F* are of the same polarity.

Some manufacturers use only one-half as many interpoles as could be used, and by so doing use less iron and copper in the construction of the machines, claiming that this makes for a cooler machine in that it gives better ventilation, and that it reduces the cost.

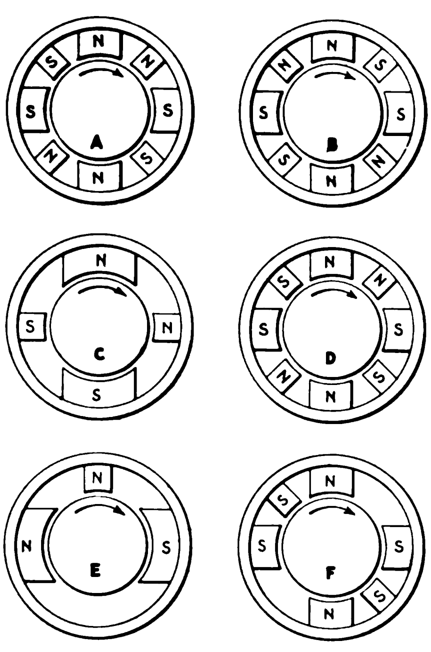
On some small motors where the interpole winding has become damaged I have cut out the interpole entirely, and kept the motor in service while we were rewinding it.

I believe that if K. W. F. will study the accompanying diagrams carefully he will understand why the polarity of the interpoles was the same in some cases, whereas in other cases it was opposite.

J. W. BANTAU.

Los Angeles, Calif.

This shows the proper polarity of interpoles with respect to field poles and the various combinations employed.



PROBABLY K. W. F. has operated motors or generators which were not fitted with interpoles. If so, he knows that it is necessary to shift the brushes of such machines forward in the case of a generator and backward in the case of a motor, in order to obtain satisfactory commutation under load. The reason for this shifting of the brushes is to bring into a magnetic field of the proper polarity, those coils of the armature winding which are undergoing commutation. With a generator the brushes are shifted forward; hence the proper polarity for commutation is the same as that of the next successive main pole in the direction of rotation. In a motor the correct polarity, as the brushes are shifted backward, is the same as that of the preceding main pole in the direction of rotation.

In an interpole motor or generator, instead of shifting the brushes they remain on the neutral, and a portion of the proper main pole, so to speak, is brought to the proper position with respect to the coils undergoing commutation.

Consequently, in all motors fitted with properly-connected interpoles the polarity will always be as follows, proceding around the commutator in the direction of rotation, N-n-S-s-N-n-S-s.

In an interpole generator the sequence will be N-s-S-n-N-s-S-n. In these arrangements, capital letters indicate main poles, and small letters, interpoles.

In machines using fewer interpoles than there are main poles, these interpoles which are used will always have the same polarity as they would if the full number of interpoles were used. Thus, the answer to K. W. F.'s other question as to the correctness of polarity he has observed when only two interpoles were used, will depend upon the arrangement of the interpoles. He can check the polarity, however, by the above method.

J. M. WALSH.

Assistant Chief Engineer,
Gurney Elevator Co.,
New York City.

Electrical Service

AROUND THE WORKS

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Importance of Skin Effect in Overheating of Cables

THERE was considerable discussion in the Question and Answer section of the March INDUSTRIAL ENGINEER about a question signed E.M.D., Bellingham, Wash., regarding the heating of some heavy cables. In this discussion, it struck me as rather peculiar that no mention or suggestion of any kind was made regarding skin effect. The increase in the resistance of a 1,000,000-circ. mil conductor at 60 cycles due to skin effect would be approximately 9.6 per cent, whereas the increase in the case of a 2,000,000-circ. mil cable would probably be nearer 25 per cent.

When large, round conductors are used for low-voltage, heavy-duty alternating-current service, it is generally considered good practice to use rope core cable and many of the large companies recommend its use for cables of 750,000-circ. mil area and larger.

Skin effect is quite commonly confused with self-induction, but although it is primarily caused by the same magnetic field, it is not in any other way identified with it. As voltage drop and loss of energy are the results of such skin effect, this is by no means a negligible factor in cables of the size under discussion. It has no doubt, contributed its share in the degree mentioned, together with the other factors brought out in the discussion.

Lawrence, Mass. B. W. SCOTT.

Method of Locating Grounded Coil in A. C. Generator

RECENTLY a grounded coil in a 750-kw., 2,200-volt, three-phase a.c. generator caused disturbances in a telephone system and in a radio station in the vicinity of the plant, although there was no other evidence of this condition.

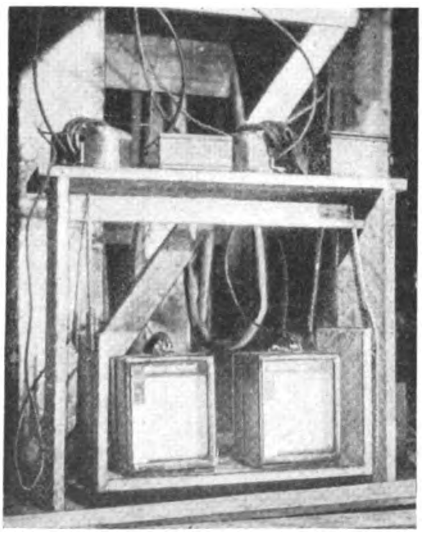
In order to find the faulty coil an ungrounded 110-volt a.c. supply circuit was connected directly to the terminals and to the frame of the alternator. This circuit drew 15 amp. on the grounded phase at 110 volts. One terminal of an a.c. voltmeter was also grounded to the frame of the alternator. The other terminal of the voltmeter was connected to an ordinary shoemaker's awl, the sharp point of which was used to pierce the insulation of the end connections of each coil in the grounded phase. A connection was made with each coil in turn and the readings of the voltmeter were noted. The coil showing the smallest reading was considered to be the damaged coil, although the voltmeter readings on three of the coils were so low that it was hard to determine which of these coils was the damaged one.

To locate the trouble more definitely, an ordinary telephone receiver was substituted in place of the voltmeter and when contact was made with the grounded coil there was no noise in the telephone receiver, but when contact was made with the coil on either side of the grounded coil the telephone could be heard several feet away. Consequently, it was very easy to find the exact location of the damaged coil, which was removed and repaired without seriously disturbing the other windings. HARRY J. ACHEE.

District Line Supt.,
Southwestern Light & Power Co.,
Elk City, Okla.

Supporting Graphic Meters to Overcome Vibration

IN A PLANT where it was necessary to run an extended test that required the use of graphic meters, it was found that the first records were of little value, due to vibration transmitted to the pens of the meters. In order to overcome the effects of vibration, it was decided to suspend the meters on springs.



The graphic meters were placed on a platform suspended on springs, underneath the testing bench.

For this purpose a test bench with a top large enough to accommodate the remainder of the testing equipment, was set up as shown in the illustration. A strip of wood was nailed between the legs of the bench and a platform of the proper size for the graphic meters was suspended from the strip by means of two pieces of window chain, to each end of which spiral springs of suitable strength were fastened.

There was no further trouble from vibration and when the test was concluded the chains and springs were salvaged for future use in tests of this nature. W. L. STEVENS.

New Westminster, B. C., Can.

Simple Tests for Determining Condition of Transformers

DEFECTS in transformers are often very apparent, but there are many times when it is necessary to employ some method for testing the condition of such equipment. Before testing the coils electrically, it is well to inspect the transformers on the outside, to see if the leads are intact and their insulation is in good condition.

First, check up all porcelain bushings to see if any are cracked. If not, they should be firmly fastened in the compound which holds them to the case. Also, inspect the leads to see if they have been siphoning oil. In case they are oil-soaked, replace them with new leads that have had a length of insulation cut away so that it will terminate above the oil level. After sweating the strands solid for several inches back from the end of the wire, tape with varnished cambric to stop the oil from creeping up the insulation again.

Ordinarily oil leaks are very objectionable and as the oil used in transformers has a great tendency to leak through the threads in the casing, it is best to inspect carefully all plugs, drain cocks, oil level gages and thermometers for signs of oil leaks. Leaking threads can generally be put in good condition by taking out the conduit or plug that is giving trouble and running the threads over with a die. The tapped hole in the casing can then be cleaned out with a tap. Before replacing the plug or conduit, cover the threads with white lead, litharge and glycerine, thick shellac, or even LePage's glue which has been used successfully for keeping the joints tight. In any event, whatever is applied to this joint should be allowed to dry thoroughly before subjecting it to oil; otherwise the oil is very likely to seep through it.

An electrical ground test should now be applied to the low-voltage side of the

transformer. The testing current should be applied gradually and brought up to the point where its voltage represents twice the rated voltage plus 1,000, the highest voltage being applied for 1 minute.

The high-voltage side of the transformer should now be tested to ground. In this case, it is generally necessary to employ unusually high voltages; consequently it is necessary to take extra precautions to safeguard those running the test.

In our repair shop we make use of a 30,000-volt, Type K, General Electric transformer for testing transformers and oil samples. This test transformer has a small voltage regulator on the low-voltage side that can be connected to the 110-volt or 220-volt a.c. supply. Thus it is easy to raise the voltage slowly, step by step, from zero to 30,000.

When making a ground test on the primary side the test leads should be connected to all primary leads in sequence, and the other leads can be connected alternately to the core and to the transformer case. During this test the secondary leads should be grounded, in order to avoid any stresses that might be set up in the windings. In case the transformer is very old, it will be best, however, to reduce the test voltage somewhat.

The next check will be between the primary and secondary windings. This test is carried out by connecting one test lead to the primary wires and the other to the secondary wires. The highest test voltage in this case should also be continued for one minute. Before making this test be sure that the windings are clean and, above all, dry. If in doubt about this, use a Megger and measure the insulation resistance of both windings. If the reading is low, the coils should be dried out, and another reading taken before applying the high-voltage test; otherwise the windings are likely to be damaged.

After these ground tests have been made, it is well to measure the ratio of the transformer. This will show whether the windings are intact, and also whether any sections of the windings are shorted. Ordinarily we find it easier to apply voltage to the low-voltage side and measure the output high-voltage side with a potential transformer and meter. In this case the readings of the primary and secondary should agree with the voltage ratings on the nameplate.

When it is possible to do so, it is well to give the transformer the following insulation test: Use double the rated frequency and apply voltage gradually to the low-tension windings of the transformer, building up the voltage until it reaches twice the normal voltage. The higher frequency has a tendency to keep the current from exceeding the rating of the coil. This test subjects the insulation between adjacent turns and layers to twice its usual voltage and should show up partial shorts, poor insulation, and the like. In making this test one should always have the protection of circuit breakers or fuses in the circuit ahead of the testing apparatus in order to protect it and the apparatus under test.

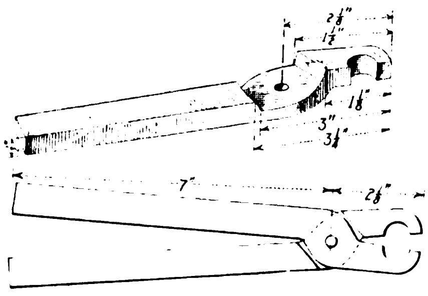
If it is desired to apply the full-load current to the secondary windings, connect the secondary terminals through an ammeter and then apply a low voltage to the primary windings. Raise this voltage gradually until the ammeter indicates that rated full-load current is flowing. During this test, one can tell if the transformer heats while operating under full load. Also, this is a good way to dry out the windings if the transformer has been idle.

Whenever applying full-load current to the secondary, it is absolutely necessary that the transformer case be filled with oil. Trouble often results if the dielectric strength of transformer oil is not kept up to the proper standard which has been set at a value of 22,000 volts with 1-in. disks spaced 0.1 in. apart, or 40,000 volts with 0.5-in. disks spaced 0.2 in. apart.

EDWIN W. LINDOP.
Los Angeles, Calif.

How to Make Inexpensive and Durable Fuse Puller

ALTHOUGH fiber fuse pullers can be purchased, many electricians prefer to make their own. Some idea of the life of a home-made fuse puller may be judged from the fact that the one I am using was made by me over 13 years ago.



Red fiber is a good material from which to make a fuse puller.

The accompanying sketch gives the dimensions of a puller that will handle cartridge fuses up to 100-amp. rating. If larger fuses are to be handled, the dimensions of the puller must be increased.

It was made from ⅛-in. red fiber. This was first cut to the approximate shape with a hacksaw; then the surface was smoothed on an emery wheel and later with a file.

CHAS. A. PETERSON.
Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Poor Workmanship and Neglect Cause Shutdown of Plant

PRODUCTION was held up recently in a plant due to a combination of troubles in the control of a 30-hp., 220-volt, three-phase, squirrel-cage, induction motor. This motor was operated from an auto-starter. Several attempts to start the motor were unsuccessful; so we started out to locate the cause of the trouble.

First of all, the circuits were checked up for defects. Then the auto-starter was inspected. An examination soon revealed the fact that the oil in it had been allowed to become very low with the result that the contacts were not covered. These contacts were badly burned from arcing, and when the starter was operated a few contacts would occasionally make a hit-or-miss connection with the result that the motor would only hum, due to an open phase.

Nearly a day's work was required to repair the auto-starter, as no spare contacts were on hand, and upon completion of the job the same open-phase hum was evident. The wiring from the starter to the motor was again checked and it was found that one of the phase wires sometimes tested out open, and at other times, closed.

Further investigation disclosed that on the original installation of the motor the terminal lugs were bolted with lockwashers to the phase-wire lugs. When the motor was later removed to a new location, the same materials, with one exception, were used in the new installation. This exception was the lockwashers, so the whole trouble with the exception of pitted contacts in the auto-starter, was a loose connection between the two copper lugs on one phase wire. The vibration of the motor had caused the bolt to become loose and resulted in a high-resistance joint in the circuit, which became worn away by arcing until an open joint resulted. After we had made a secure joint, the motor operated satisfactorily.

NATHANIEL W. BLANCHARD.
Inwood, L. I., N. Y.

Motor Breakdown Prevented by Insulation Tests

A MOTOR which was installed near a battery room door would have run satisfactorily for several years if the battery attendants had taken the pains to keep this door closed. As the result of leaving this door open quite frequently, acid fumes from the battery room ate away the insulation to such an extent that a Megger test on the machine showed that parts of the insulation had a dielectric strength that was far below the standard for the successful operation of this motor. The cotton covering in places on the armature coils was nearly eaten away, although the field magnet coils were found to be, on the average, in better condition, due to the fact that a good shellac varnish had been applied in quantity.

As the fault was discovered in time, we were able to reinsulate the coils on the armature; otherwise we would have had a complete breakdown, which would probably have been much more costly in time and money.

Our experience with this motor indicates the necessity of making periodical insulation resistance tests and keeping a close watch on equipment exposed to acid fumes. Furthermore every effort should be made to minimize such exposure. In this case, we installed double doors leading to the battery room. Only one door is open at a time, thus reducing the possibility of acid fumes escaping from the battery room.

W. E. WARNER.
Shefford, Bedfordshire, England.

MECHANICAL MAINTENANCE OF Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Emergency Speed Reducer Built from Auto Steering Gear

INDUSTRIAL operating men who are convenient to mill supply houses and the branch offices of various manufacturers can usually be supplied without a great deal of inconvenience with miscellaneous pieces of equipment that they need.

Many plants that are operating away from the larger industrial centers, however, sometimes have more difficulty in obtaining parts in an emergency and the exercise of considerable ingenuity may be required to provide a satisfactory substitute.

One problem which we faced recently may be of interest to other men in case of a similar emergency. A small pump was to be driven by a fractional-horsepower motor. The motor was rated at 1,760 r.p.m. and the speed required for the pump was about 200 r.p.m. A belt drive could not be used because the space was too small and the location otherwise unsuited to it. It was obvious that a small reduction gear unit would do the work very well, but none was to be had on short notice in this immediate locality.

Finally the worm and worm wheel of an automobile steering gear were thought of. A visit to an auto wrecking shop disclosed the gear ratio of one such device was 8:1. This was mounted on a plank in line with the motor to make a direct-connected drive. A piece of rubber hose, in the emergency, served as a flexible coupling between the motor shaft and the worm shaft. The low speed, approximately 220 r.p.m., was taken off the worm gear shaft which extended at a right angle to the gear unit. The entire assembly operated very satisfactorily and economically solved our emergency problem.

W. L. STEVENS.
New Westminster, B. C., Can.

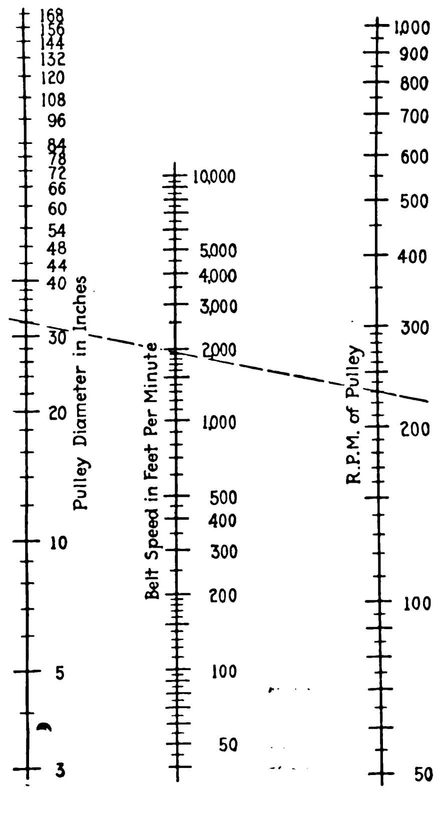
Simple Chart for Determining Belt Speed

FOR effective operation of leather belts in the transmission of power, it is always well to keep the belt speed high because the power transmitted depends upon the speed and the size of the belt. Thus, at high speeds narrower belts can be used. In any installation it is usually possible to lay out a drive for any one of a number of belt speeds because a constant reduction ratio between the pulleys may be obtained by the use of several different combinations. To check the belt speed of these combinations, operating men will find the accompanying chart very convenient. To use this chart, it is necessary to know only the pulley diameter in inches and the revolutions per minute of the pulley; both of these factors are usually known, or determined in advance.

With this chart the belt speed in feet per minute is determined by the intersection on the center scale of a straight line drawn from the point on the scale at the left, corresponding to the pulley diameter in inches, to the point corresponding to the r.p.m. of the pulley on the scale at the right.

The chart below is used as follows, for determining belt speed.

Assume that a 32-in. pulley is located on a shaft operating at 230 r.p.m. Place a straight-edge or ruler at 32 on the scale at the left and at 230 on the scale at the right. The intersection with the center scale gives the belt speed as 1,900 f.p.m. This chart was designed and copyrighted by J. E. Rhoads & Sons, Philadelphia, Pa.



This same chart can be used to determine the surface speed of pulleys in the same way.

Familiarity with Care of Bearings in Emergency Prevented Breakdown

KNOWING what to expect and what to do when the unexpected occurs are two important factors in decreasing breakdowns and other interruptions to service. Men who can train their working force along these lines very frequently give the appearance of having nothing to do much of the time.

As a matter of fact, this type of man is paid for what he knows and because he has his department so well organized that it runs smoothly without his constant attendance. Being paid for "what he knows" means knowing what to do in an emergency and doing the right thing quickly. His real value is soon demonstrated when the emergency comes and he is almost instantly master of the situation. Under such teaching the men in the maintenance crews learn how to meet unusual situations quickly and properly.

A recent happening illustrates this point, although in this case the principal figure was a man who had been shifted at his own request from the maintenance crew to an easier job as night watchman. For 4 hr. every night he had some hold-over work to perform and after that he was merely a watchman. However, he had been well schooled in maintenance work and knew enough of the operation of the equipment to handle any emergency.

The nickel plating department in this plant always keeps the tanks in operation until 9 p.m. at which time plating generators are shut down. The night man was instructed in the manipulation of the various controls, but was absolutely forbidden to remove anything from the plating tanks.

One night he heard a noise at the far end of the room near the generators. Hastening there, he saw a faint puff of smoke near the end of one machine. This, and the labored sound of the machine, told him that a bearing was hot and cutting. The natural move would have been to stop the motor driving the generator, but instead he cut out the field excitation. This permitted the armature to revolve idle, with no load on the bearings other than its own weight.

His idea was to keep the machine running because he knew that plating could be carried on by switching the tank to another machine. He also knew that if he stopped the machine with the bearing so hot, nothing could pre-

vent it from "seizing" on the shaft. If that did occur, the repair crew would find the shaft frozen fast and both the shaft and the babbitt bearing would be deeply scored.

By cutting off the excitation he first removed all the friction possible from the bearing. He then cooled it down by flushing out the bearing and well with fresh oil; this was poured in and the drain plug opened to take off the excess and any foreign matter. Later in the night he shut down the machine, but not until the bearing was cool.

In the morning the repair crew decided that they could keep the machine in service as it was, until Saturday. Thus, this man's quick thinking turned what might have been a costly breakdown into a mere routine bearing renewal. DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Simple Device for Protecting Heater Units When Blower Belt Breaks

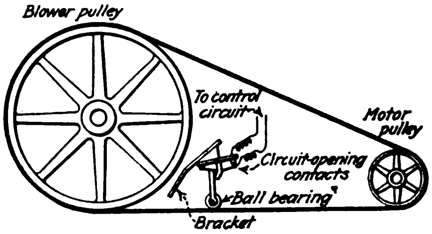
THE office building of the company with which I am associated is heated by a system of Glo-bar heating elements. A group of these elements is installed at each vent hole, and air for distributing this heat comes from a large belt-driven blower in the basement. In order to safeguard this installation from trouble that would be likely to occur at any time I made the protective device described below.

The purpose of this device is to cut out the magnetic switches connected to the circuit supplying the heating elements in case the blower stops due to the belt coming off or breaking. The motor driving the blower is operated from a General Electric 7,006 push-button magnetic switch. Energy for operating the coils on the magnetic switches controlling the heaters is also taken from the push-button switch, so that the heat is turned on whenever the motor is running.

A stop-button unit was taken from a spare General Electric compensator, and in place of the $\frac{1}{4}$-in. pin extending from it, a piece of 16-gage iron about $\frac{1}{2}$ in. wide and 12 in. long, bent in a U-shape with about $\frac{3}{8}$ in. between the sides, was installed.

A ball bearing about $1\frac{1}{2}$ in. in diameter and $\frac{1}{2}$ in. wide was then placed on a small shaft driven through the end of this extending arm, as shown in the illustration. A coil spring was made to take the place of the original piece of flat spring steel in the push-button unit. The original spring was too weak to withstand the constant pressure and motion that were necessary in the operation of the new unit. A small grease cup was installed on the ball bearing shaft to keep the bearing lubricated.

The whole unit was then installed in such manner that the ball bearing rides the blower belt on the inside. A bracket for holding the belt contact device was installed on the bottom of a staircase running close to the blower pulley. This device makes contact on the bottom, or the pull side, of the belt so that a comparatively uniform tension is maintained against the contact of the stop-button unit.



When the belt tension is released the control circuit of the motor and heating elements is opened.

The control circuit of the switch supplying the motor was cut open and connected to two wires run in flexible conduit to the new belt-riding contactor. If the belt should break or slide off the pulleys the tension against the ball bearing, which holds the control circuit closed, would be released, thus stopping the motor and opening the heater circuit switches.

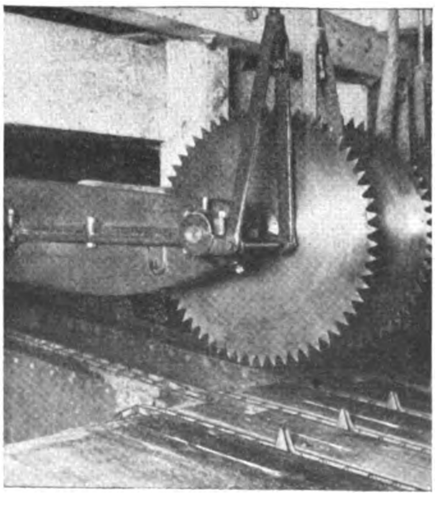
Pinedale, Calif. D. W. HAIRE.

Use of Roller Chain for Saw Trimmer Drive

THE lumber industry puts many severe tests upon the drives to the various machines that are found in the modern sawmill. Operating men in this industry are giving particular attention to these drive problems and their solution. For example. a roller chain drive, is being used on a 40-saw Prescott trimmer, recently installed in the plant of the Eclipse Mill Co., Everett, Wash., as shown in the accompanying illustration. Each drive is entirely enclosed and is in an individual casing, which also contains the oil bath in which the chain dips to lubricate both the roller joints and the sprocket contacts.

The chain used in these drives is Diamond No. 149, $\frac{5}{8}$-in. roller, manufactured by the Diamond Chain & Mfg. Co., Indianapolis, Ind. The drive shaft sprockets have 40 teeth and the saw arbor shaft, 17 teeth; the shafts are on 2-ft. centers. The saws shown in the illustration are 20 in. in diameter and are driven at 1,900 r.p.m.

Close-up view of one of the roller-chain-driven saws on a 40-saw trimmer in the Eclipse Mill, Everett, Wash.



Compactness, positive drive features, and elimination of maintenance were, it is said, some of the reasons influencing the selection of this type of drive for this machine.

Decreasing Pulley Wear from Abrasive Dust on Belts

BELTS operating in an atmosphere of abrasive dust often grind away the pulley surface, particularly at the crown. Although it is usually considered better practice to run belts with the slack side on top, it may in such cases, be best to drive with the tight side on the top, with a resulting increase in belt and pulley life and efficiency.

Where a considerable amount of dust is flying about, particularly if this is abrasive, if the slack side is at the bottom the belt flap or vibration, which always occurs on the slack side, will tend to shake the dust off the belt and so prevent at least part of it from being carried around the pulleys and worked into the belt to wear away the pulley surface as the belt slips. All of the dust will not be displaced by the flapping, but a good deal of it will be.

When the tight side of a smoothly moving belt is at the bottom it presents an ideal place for dust to settle on. In such cases, the advantages gained by having the slack side on top are easily counterbalanced by the longer belt and pulley life and increased efficiency obtained by running the belt with the slack side on the bottom.

Easy Method of Indicating Location of Oil Holes to New Oilers

ALTOGETHER too often a new oiler or new machine operator will have to hunt out the oil holes himself when taking over his job. Those in charge often forget, even though they know that adequate and regular lubrication is very important, that the location of all the oil holes on the equipment is not known to a new operator and he may miss some owing to his ignorance of their position.

For this reason it is advisable to have the number of parts requiring oiling and their position recorded on a card hung on the machine. Generally the manufacturer of the machine supplies such a list, or a diagram or drawing showing the location of all parts that require lubrication. This could be mounted either on, or convenient to, the machine and so always be available for reference in case a new man is required to do the oiling.

I have known instances in which parts have run for some time without oil owing to the location of an oil hole not being known. Fortunately, the results were only increased wear; a breakdown had been avoided in these instances only because the parts were lightly loaded and had ample clearance.

W. E. WARNER.

Shefford, Bedfordshire, England.

New Equipment

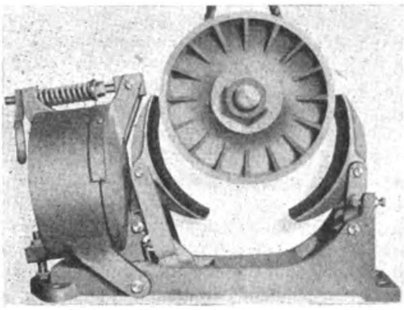
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Electric Shoe Brake

A NEW shoe brake, announced by the Electric Controller and Mfg. Co., 2700 East 79th St., Cleveland, Ohio, is designed to meet the demand for a shoe brake giving longer life of shoe linings and permitting removal of the motor armature with brake wheel in place without the necessity of taking the brake apart or disturbing any of its adjustments.

The E. C. & M. Type WB brake is claimed to be radically different from any other shoe brake design in that no levers or rods pass over the top of the brake wheel. The brake shoe arms are



Electric Controller and Mfg. Co. Type WB Brake.

caused to operate in opposite directions by means of a simple lever movement having the connecting link within the base below the wheel. Steel castings and oversized bearing pins are furnished to assure smooth operation of the brake.

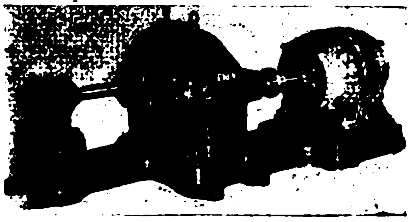
The brake shoe linings are asbestos interwoven with wire and molded to shape under heavy pressure. The linings are $\frac{1}{2}$ in. thick on the smallest size brake and $\frac{5}{8}$ in. thick on the larger size.

Speed Reducers

A NEW line of speed reducers has recently been put on the market by the Falk Corporation, Milwaukee, Wis. These units feature the Falk continuous tooth and all-steel herringbone gears.

A special design of housing eliminates any internal ribs, projections or complicated cores. In this way lubrication has been simplified and, it is claimed, all possibility of dirt or core sand working into the gears is definitely removed. Added features are the airplane-type, steel-backed, babbitt-lined bearings that are capable of carrying heavier loads and an improved, automatic, continuous-lubrication system.

This line of reducers covers a certain number of standard reduction ratios,



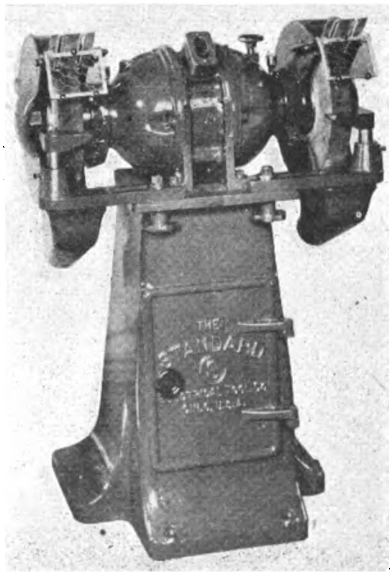
Falk Double Reduction Unit No. 7D

and standard motor beds have been adopted for them. The reducers are made in three types—single reduction for ratios up to 9:1, double reduction for ratios up to 70:1, and triple reduction for ratios up to 300:1.

Ball-Bearing Grinders

REDESIGNING of their complete line of electric grinding, polishing, and buffing machines has been announced by the Standard Electrical Tool Co., Cincinnati, Ohio. These units all have built-in motor and ball bearings. The accompanying illustration shows the new ball-bearing, pedestal-type grinder which is manufactured in two sizes of 3- and 5-hp. rated capacity. The 40-deg. motors and push-button control used in these grinders are of General Electric manufacture. The armature shafts are made of $3\frac{1}{2}$ per cent nickel steel.

The SKF bearings are encased in dust-proof chambers. The emery wheel guards are of the hinge door type with exhaust connections. A spark breaker



Standard Electrical Tool Ball-Bearing Pedestal-Type Grinder.

and a polished, wire-glass eye shield are fitted on these guards.

The 3-hp. grinder carries emery wheels 12 in. x 2 in. or 14 in. x 2 in. and weighs 704 lb. The 5-hp. grinder carries wheels 18 in. x 3 in. and 20 in. x 3 in. and weighs 1,190 lb.

Motor-Driven Siren

MARKETING of the Triple-A siren designed for use as a fire alarm or as a signal for starting and stopping work is announced by the Federal Electric Co., 8700 S. State St., Chicago, Ill.

As the name indicates, this siren consists of three sirens mounted on a triangular base. These sirens are connected in parallel and are controlled from one push button switch, about 1 hp. being needed to operated them.

The tone of each siren is different and under normal conditions it is claimed that the unit has a sound radius of $\frac{3}{8}$ to $\frac{1}{2}$ mile in every direction.

The motor-housings and stator and rotor frames are die-cast aluminum.

Federal Electric Co. Triple-A Siren.

The horns and weather housings over the motor cases are seamless, deep-spun aluminum, the units being entirely inclosed.

The Triple-A siren is finished in red Duco and weighs about 40 lb.

Armored Cap Plugs

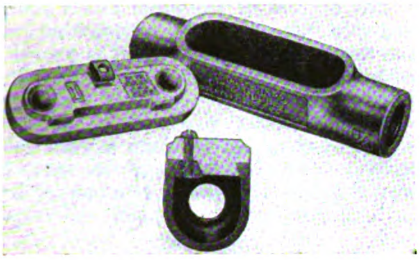
A NEW line of armored attachment plugs known as the RS and SS types has just been introduced to the trade by the Arrow Electric Co., Hartford, Conn. One of the features of these plugs is the fact that the composition cap is covered with a ribbed steel shell to protect it from damage due to blows or hard usage.

The SS plug cap differs from the RS type in that it is provided with a cord-gripping feature for protecting the cord.

Conduit Fittings

ANNOUNCEMENT of a new line of Obround condulets which, it is claimed, incorporate a new method of fastening covers and wiring devices to a condulet by means of the Wedge-Nut fastener, has been made by the Crouse-Hinds Co., Syracuse, N. Y. A few turns of the screw driver is all that is needed to secure the cover or wiring device to the condulet.

With this new form of construction



Obround Condulets Made by the Crouse-Hinds Co.

there are no screws projecting inwardly to injure the conductors, and because of the unobstructed cover opening they may be easily pulled through. The unobstructed cover opening and large wiring chamber also facilitate the splicing and taping of wires.

Another feature is that even in out-of-the-way places the covers and wiring devices may be conveniently installed as they can be turned so as to bring the fastening screws into an accessible position. These condulets are made in many different types for various uses.

Three-Wire System Switches

TWO-POLE switches with a solid neutral block for use on three-wire grounded systems have just been developed by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., in sizes ranging from 30- to 600-amp. rating. This type of switch is designed to utilize the advantages of reduced size made possible by using a solid neutral without the third switch blade, the size being reduced to that of a standard two-wire switch.

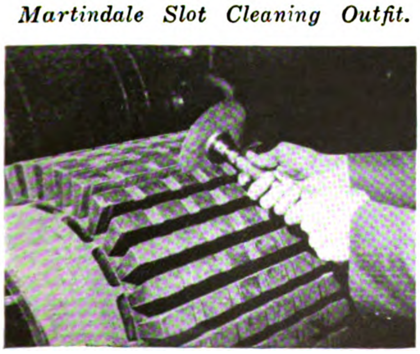
The 30-amp. size switch is of the OO type, the 60-, 100- and 200-amp. sizes are of the WK-62 type, and the 400- and 600-amp. sizes are of the WK-60 type. All the types up to 200 amp. rating may be supplied with a removable end adapted to a meter trip when it is desired to mount the meter in conjunction with the switch.

Slot Cleaning Outfit

MARKETING of a new slot cleaning device, which is shown in the illustration, has been announced by The Martindale Electric Co., 1260 West 4th St., Cleveland, Ohio.

This outfit comprises a $\frac{1}{4}$-hp., 1,750 r.p.m., Westinghouse motor, a 4-ft. flexible shaft, a ball-bearing handpiece and

Martindale Slot Cleaning Outfit.

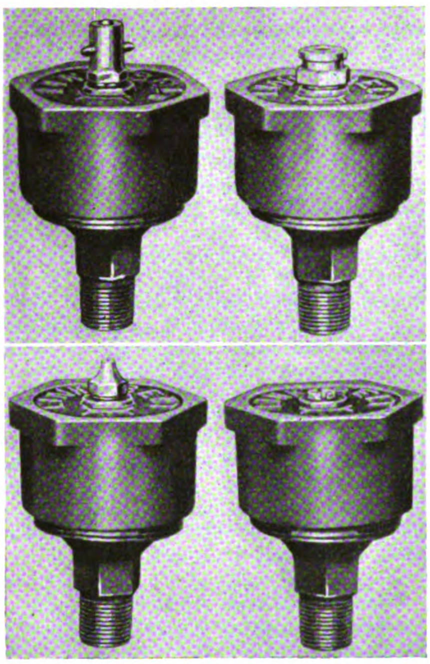


a disk holder. The grinding disks are thin and flexible and range from 4 to 8 in. in diameter. They are ordinarily used in pairs, placed back to back, so that a grinding surface is available on both sides. A $\frac{1}{16}$-in. thick fibre stiffener may be placed between the disks to give additional stiffness.

It is stated that this outfit will quickly remove all old insulation and burrs from slots, as well as bad burns that sometimes result from a grounded coil, in which case the copper and iron are fused together. It is also recommended for removing old solder from riser necks.

Compression Grease Cup With Alemite Fitting

PRODUCTION and distribution of the Hex-Top malleable-iron, compression grease cup provided with various types of Alemite and Alemite-Zerk fittings, as shown in the accompanying



Link-Belt Hex-Top Compression Grease Cup With Alemite Fittings.

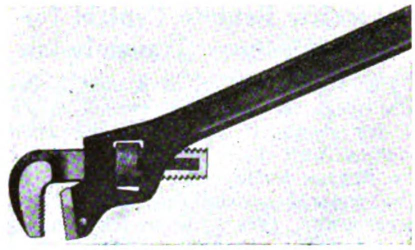
illustration, has been announced by the Link-Belt Co., 300 W. Pershing Road, Chicago, Ill.

The Hex-Top or six-sided head offers a ready grip for the hand or wrench, if necessary. When it is desired to refill, the cap is unscrewed until almost off and the grease applied through the Alemite or Zerk fitting. In this way it is not necessary to open the cup and so expose the grease to dusty air.

It is stated that this unit combines the advantages of both the compression grease cup with its reservoir of lubricant and the easy filling features of the grease gun.

Pipe Wrench

ANNOUNCEMENT is made by the Lawson Mfg. Co., Cleveland, Ohio, of an all-drop-forged-steel, hardened and tempered pipe wrench which is



Lawson Pipe Wrench with Angle Handle.

shown in the illustration. It contains only five parts.

As will be noted, one of the principle features of this wrench is the angle at which the handle is placed with respect to the jaws. This makes it possible to give one-eighth of a turn to a pipe lying parallel with a floor, wall or ceiling, where it would be difficult to use a straight-handled wrench. It is also said to be unusually easy to use in tight corners or among other pipes or obstructions, and that the design makes it possible to remove the wrench from a pipe by lifting it straight off.

Trickle Battery Chargers

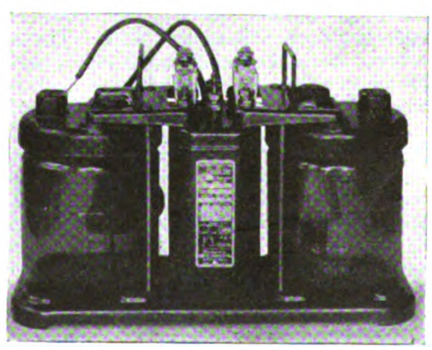
TWO heavy-duty Balkite trickle chargers for industrial use, Types RA and RB, have recently been placed on the market by the Fansteel Products Co., North Chicago, Ill. These two units are used where there is a demand for a continuous charger to trickle charge or float small-capacity, low-voltage storage batteries for fire alarm, signal, clock, recorder, telegraph and telephone systems, switch-operating batteries, or others where the average current drain will not exceed $\frac{3}{4}$ amp.

These units consist of an electrolytic rectifier, transformer, and resistance unit, compactly assembled for shelf mounting. The cell contains a tantalum (Balkite) and a lead electrode immersed in sulphuric acid electrolyte.

The resistance unit, in connection with the transformer taps, gives full control of the charging rate from 0 to a maximum of $\frac{3}{4}$ amp.

The Type RA single rectifier cell unit is used to charge from 1 to 6 cells, and the Type RB with two rectifier cells, as shown in the accompanying illustration, is used to charge from 7 to 12 cells. These units are available for 110- or 220-volt service and will operate on 25- to 140-cycle circuits.

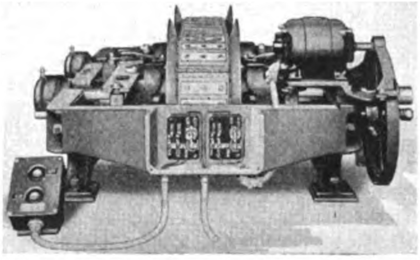
Type RB, Heavy-Duty Balkite Trickle Charger.



Electric Remote Control for Variable-Speed Transmission

RECENT addition of a push-button-operated, electrical remote control to its standard variable-speed transmission unit has been announced by the Reeves Pulley Co., Columbus, Ind. The control consists of a fractional-horsepower, reversible motor mounted on a bracket above the shifting screw of the transmission as shown in the illustration, and connected to the screw by a single reduction of spur gears. This motor is started in either direction by one or more push-button stations operating through a magnetic switch of special design.

Because of the small amount of power consumed when shifting the transmission, it is generally possible to connect the actuating motor to a standard lighting circuit for Reeves transmissions up to and including the No. 7 size. In case the operator should hold the push-button beyond the "slow" or "fast" limits of speed, a patented safety clutch prevents jamming of the motor or transmission. The motor runs only when the "fast" or the "slow" button is depressed. Hence the speed of the transmission can be controlled within small limits.



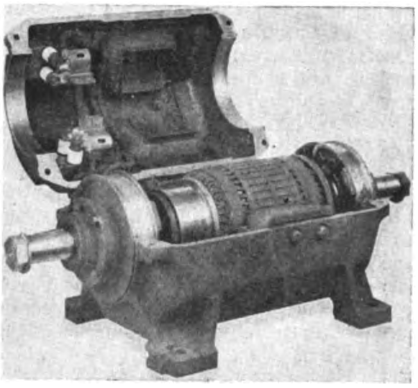
Reeves Push-Button-Operated Electrical Remote Control for Variable-Speed Transmission.

This electrical remote control is said to be of particular value in connection with machines of considerable length, such as corrugating machines, traveling bread ovens, material handling conveyors, and so on, where it is inconvenient for the operator to leave the machine to adjust the speed transmission by hand. A tachometer may be located at any or all push-buttons so that the operator may know at all times the exact speed of the machine.

Steel Mill Motor

A NEW line of steel mill motors, to be known as the MD-400 series, has been announced by the General Electric Co., Schenectady, N. Y. These motors, it is claimed, have been designed in collaboration with the Standards Committee of the Association of Iron & Steel Electrical Engineers and fully meet the specifications of that body. The motors are of the roller-bearing type, but sleeve bearings can be supplied at the option of the purchaser.

The new line involves improved mechanical construction, more efficient use of materials and a refinement of details, as compared with the superseded line of MD-100 motors. Parts are more accessible and, at the same time, are better protected. Heat-resisting insulation (mica and asbestos) conforming to A.I.E.E. class B insulation specifications is employed in these motors, which are said to have the ability to commutate high overloads. They have also been designed to permit exceedingly rapid acceleration and frequent reversals.

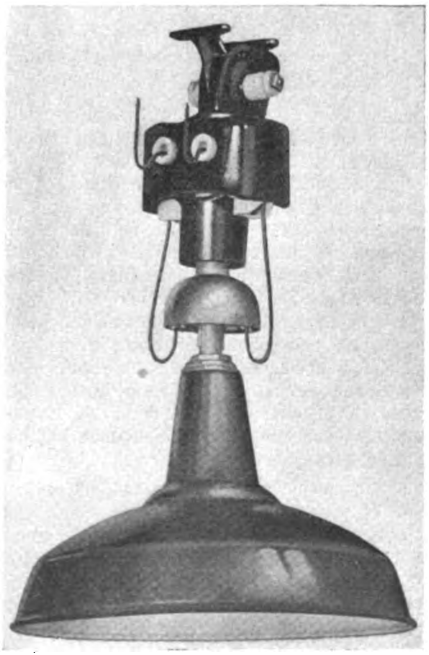


General Electric MD-400 Series Steel Mill Motor.

Lamp Shock Absorber

ANNOUNCEMENT of a shock absorber for industrial lamps has been made by the Thompson Electric Co., 1438 West Ninth St., Cleveland, Ohio. This shock absorber consists principally of a spring, which is designed to accommodate lamps of various weights, a canopy, a grid-plate and a stem, the latter three parts being malleable-iron castings. No screws or bolts are used in this device and all parts except the spring, are galvanized. The canopy is weatherproof and has a 1-in. standard thread at the top. The construction of the grid plate is said to be such that no matter how much it may be tilted by the swaying of the lamp, it will not drop out.

Thompson Shock Absorber for Industrial Lighting Units.



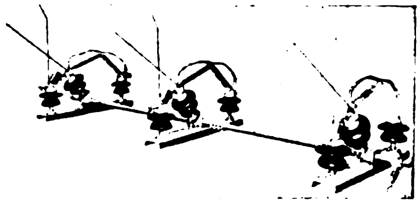
The bottom of the stem has a standard ½-in. pipe thread for screwing into the top of the reflector, and is provided with ribs to prevent it from rotating in the grid-plate.

This resilient support for a lamp may be assembled between a Thompson hanger and bracket, or it may be screwed directly into a 1-in. outlet box or fitting.

Air-Break Disconnecting Switch

MARKETING of new gang-operated, air-break disconnecting switches designed for outdoor service has been announced by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. These switches may be operated as single-, double- or three-pole units and are available for voltages of 7,500, 15,000, 25,000, 37,000, 50,000, and 73,000 and in capacities of 400 and 600 amp. A 200-amp. rating is also available for 7,500 and 15,000 volts.

The contact fingers on these switches are of the self-closing type and have ample contact surface. Arcing horns are furnished with all upright-mounted switches, but if not required may be discarded. These switches are also furnished for inverted and vertical base mountings. The operating mechanism is of the double-toggle type, with arrangement for padlocking in both positions.



New Type RW Westinghouse Air-Break Disconnecting Switch.

Dereeler For Armature Winding Machines

MANUFACTURE of the new Chapman Compensating Tensionless Dereeler has been announced by the P. E. Chapman Electrical Works, N.E. Corner Tenth and Walnut Streets, St. Louis, Mo. The Dereeler is an auxiliary piece of apparatus for use in connection with any winding machine.

According to the manufacturer, the difficulty of taking the wire off the spool has been overcome by supplying a false head with a highly polished rim which fits the spool, preventing the wire from catching on any irregularities in the spool head. The false head is connected to the winding lathe, electrically or mechanically, so that starting and stopping the Dereeler with the lathe prevents over-feeding. It is stated that no objectionable twist is imparted to the wire when it is taken off over the spool head, and when winding wires having a single thread cover, the Dereeler compensates for the inherent twist, caused by the elasticity of the thread cover, permitting the wire to lay straight.

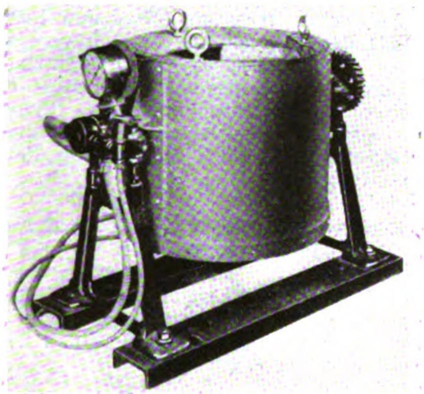
It is also claimed that whipping ac-

tion has been overcome and friction kept down by passing the wire through a damping tube which is carefully proportioned and set. In addition, there is little or no tension at any speed, allowing a sufficient margin for the drag of guiding devices and the operator's fingers, without stretching or injury to delicate coverings.

Babbitt Melting Pot

ANNOUNCEMENT is made by the Harold E. Trent Co., 439 North 12th St., Philadelphia, Pa., of a 750-lb. electrically-heated babbitt melting pot, with pouring spout and tilting mechanism, complete with automatic temperature control, as shown in the accompanying illustration.

These melting pots have, it is stated, a special cast-iron crucible, steel case, and heavy insulation. The special feature of these tilting-type pots is the



Babbitt Melting Pot Made by Harold E. Trent Co.

application of the temperature control, which is so placed as to be effective regardless of the position of the pot.

The constant use of the temperature control is of importance during the whole operation of melting and pouring bearings, so as to insure correct heating of the babbitt right up to the time it is poured.

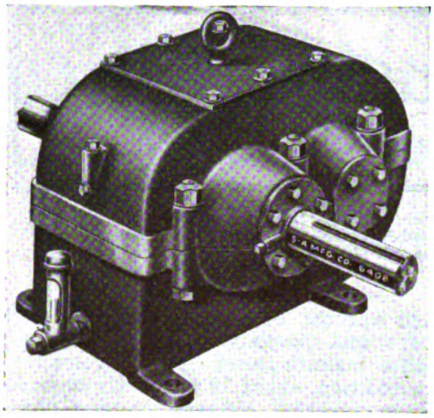
The tilting mechanism is operated by means of a handwheel. Special attention has been given to the construction of the worm gear drive, which makes the pot easy to tilt. These pots are arranged for operation on single-, two- or three-phase circuits.

Speed Reduction Unit

ANNOUNCEMENT is made by the Stephens-Adamson Mfg. Co., Aurora, Ill., of the introduction of an advanced type of speed reducer unit which is being marketed under the trade name of Speeducer.

This unit, which employs spur gears, is said to embody a number of unusual features of design. The gears and shafts are mounted in a rigid, oil-tight case, which insures the maintenance of proper alignment. The gears operate in a bath of oil, thus providing positive and ample lubrication.

Speeducer units are available in standard sizes for ratios up to 2000: 1, in capacities which range from 1 to



Stephens-Adamson Speeducer.

300 hp. For a given reduction ratio it is claimed to require less space than the ordinary open gear train.

Outdoor Substation

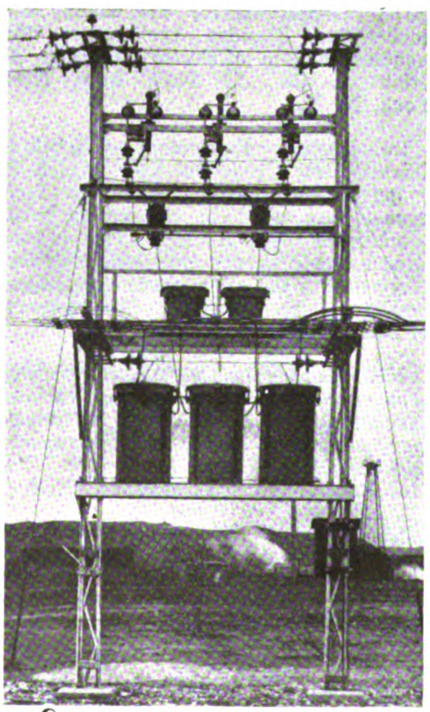
STANDARDIZED outdoor substations, particularly adapted for use in the oil fields and in other industrial applications where changes in the location of equipment may be necessary, have been made available by the Delta-Star Electric Co., 2,400 Block, Fulton St., Chicago, Ill.

These standardized substations can be quickly erected and easily moved when the load shifts, and it is claimed that they are provided with all the protective equipment of larger stations.

The unit shown in the illustration has been designed for 13,200/440-volt operation, taking care of three 50-kva. transformers. It is equipped with 27,000-volt insulators, insuring a high factor of safety.

The maximum height is 25 ft., but switching and reading of meters can be done from the ground. If in the future it is found desirable to use a ring system, a three-pole sectionalizing switch can be mounted on each pole of the steel structure.

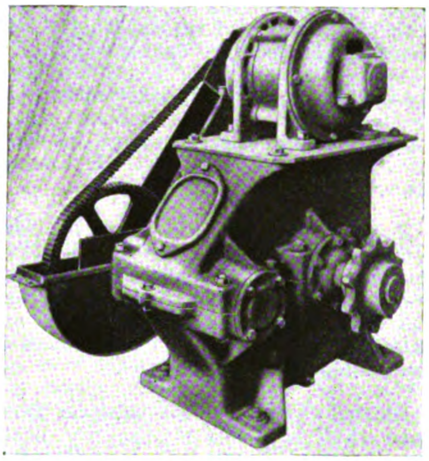
Delta-Star Outdoor Substation.



Speed Reducer Units with Silent Chain Drives

MANUFACTURE of two new types of speed reducers has been announced by H. W. Caldwell & Son Co., (Link-Belt Co. owner), Western Ave. at 17th and 18th Sts., Chicago, Ill.

The Caldwell speed reducer is a self-contained unit which combines two separate drives: a Link-Belt silent-chain drive between the motor and the high-speed shaft of the speed reducer which, in turn, gives a second reduction through a cut spur-gear drive to the low-speed shaft. The different variations in the low-speed shaft are ob-



Type A Caldwell Speed Reducer.

tained by the use of different sprocket ratios in the silent-chain drive. The reduction unit is made in two types; Type A, shown in the illustration, is designed for elevator and conveyor drives and for general industrial applications. Type B is for direct connection to screw conveyors. These units are made in sizes to give reduction ratios from 7:1 to 40:1 in Type A and up to 30:1 in Type B. Speed ratios may be changed at any time by substituting a different size of motor pinion or silent chain sprocket.

Both types of units are designed to mount the motor on top of the gear-reduction case.

Timken tapered roller bearings carried in cartridge mountings support the oversized shafts in the housing. Automatic lubrication of the cut spur gears and bearings is obtained from a large oil reservoir in the base of the housing. The chain is completely enclosed in an oil retaining case.

Type A unit is made for use with 5-, 7½-, 10-, and 15-hp. motors and Type B unit for use with motors of 3-, 5-, 7½-, 10-, 15- and 20-hp. The standard reductions listed in Book 630, which describes and prices this unit, may be obtained from the standard sizes of chains and sprockets (except for the 20-hp. unit) that are carried in stock in the various Link-Belt branches.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Distribution Specialties — A folder describes the line of G&W 100 per cent watershed capnut terminals in eight sizes and three styles, rated from 4,500 to 75,000 volts.—G&W Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Scientific Instruments — Catalog 2000 contains 72 pages of information on thermometers, barometers and various other scientific instruments of American and English manufacture, with illustrations of these.—Taylor Instrument Companies, Rochester, N. Y.

Ball Bearings—Leaflet 25 illustrates the construction and application of ball bearings of the types used in electric motors.—The New Departure Manufacturing Co., Bristol, Conn.

Babbitt Metal—A 20-page booklet contains much useful information on the characteristics and uses of babbitt, and includes a table that gives the characteristics of different brands of babbitt.—Hoyt Metal Co., Boatmen's Bank Bldg., St. Louis, Mo.

Electric Furnaces—An electric furnace that is designed for the heat treatment of small ferrous and non-ferrous parts is described in Bulletin 276.—W. S. Rockwell Co., 50 Church St., New York, N. Y.

Roller Chains—Various applications of Diamond Roller Chains are described and illustrated in Booklet 101.—Diamond Chain & Manufacturing Co., Indianapolis, Ind.

Conveyors—Various applications of the Cleveland Tram-Rail Systems are illustrated and explained in several leaflets.—Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Fans and Blowers—Bulletin 8001 contains 80 pages of descriptions and illustrations of fan and blower applications, with tables and diagrams for determining the proper size of fan or blower to be used.—American Blower Co., Detroit, Mich.

Portable Piling Machine—An 8-page booklet illustrates and describes a number of the applications of Brown Standard portable pilers and loaders.—Standard Conveyor Co., North St. Paul, Minn.

Painting Equipment—Bulletin 36-A describes the use of the Binks spray painting equipment for industrial maintenance.—Binks Spray Equipment Co., 3114-26 Carroll Ave., Chicago, Ill.

Insulated Electric Wires and Cables —A 71-page booklet gives the description, specifications, and all dimensions and ratings of the various types of bare and insulated copper wire and cable manufactured by this company. In addition, about 30 pages are devoted to engineering information and data, both in descriptive and tabular form.—Rome Wire Co., Rome, N. Y.

Limit Stops—Bulletin No. 1037 describes the Type B limit stops for use with a.c. and d.c. motors on cranes and other motor-driven machines that must be stopped automatically at certain points.—The Electric Controller & Mfg. Co., 2700 E. 79th St., Cleveland, Ohio.

Portable Electric Tools — A small circular illustrates and describes the line of Standard ball-bearing and air-cooled, high-power portable electric drills and grinders.—Standard Electrical Tool Co., 1936-46 West Eighth St., Cincinnati, Ohio.

Meters—Bulletin 74 covers the line of D-5 mercury-type watt-hour meters, containing detailed descriptions of the construction and operation, and other data regarding this equipment.—Sangamo Electric Co., Springfield, Ill.

Oil Purifier—A four-page circular describes the equipment used in the Hydroil continuous purification process by means of a bowl-type centrifugal separator. — Hydroil Sales Corporation, Lebanon, Ind.

Tachometer—Bulletin 225 describes the construction and operation and gives instructions for the use of the pocket-size Standco tachometer for measuring r.p.m. of shafts.—Herman H. Sticht & Co., 15 Park Row, New York, N. Y.

Lubricating Equipment — Circulars describe the Greas-Om-Eter, which is a spring-pressure, continuous-feed grease cup used in connection with Alemite or Zerk fittings. The cup is filled under pressure and feeds continuously due to the spring action.—Greas-Om-Eter Corporation, 460 Montgomery St., San Francisco, Calif.

Mill Motor Gossip—An interesting booklet that describes the various Clark products by means of an imaginary conversation between the various mill motors.—Clark Controller Co., 1146 East 152nd St., Cleveland, Ohio.

Short-Center Drive—A twelve-page booklet illustrates a number of applications of Pulmax short-center belt drives under unusual operating conditions.—Bird Machine Co., Pulmax Drive Division, South Walpole, Mass.

Tramrail—A 65-page catalog describes and illustrates numerous applications of the Atlas Duo-Rail system of mechanical conveying. This is an overhead tramrail system in which the carrier is supported on a double rail.—The Atlas-Chicago Co., Division of Chicago Electric Co., 740-744 West Van Buren St., Chicago, Ill.

Insulation—An announcement states that Mitchell-Rand Manufacturing Co. is now producing its line of tapes, webbings and sleevings in its own factory under its trade mark of Shield Brand. —Mitchell-Rand Manufacturing Co., 18 Vesey St., New York, N. Y.

Gravity Conveyors — A 12-page booklet describes a line of Standard gravity conveyor rolls, with particular attention to the varying types of roller bearings and their protection for the different industries in which these conveyors are used.—Standard Conveyor Co., North St. Paul, Minn.

Autovalve Arresters—Two new leaflets, L20013-H and L20149-C, have just been issued, describing the application, operation and other characteristics of Autovalve lightning arresters, Types LV and SV respectively.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Relays—Supplement No. 1 to Bulletin No. 550 covers the new Type FR line of relays. These relays are used principally in connection with contact-making instruments, meters, and similar devices. Roller-Smith Co., 233 Broadway, New York, N. Y.

Fire Extinguishers—The uses of carbonic acid gas in fighting fires are strikingly described and illustrated in a folder covering the Fyre-Freez extinguisher.—General Carbonic Co., 17 W. 46th St., New York, N. Y.

Electric Hoists—The Universal Ball Bearing Electric Hoist is the title of a folder just issued by this company. It contains a complete description, a table of weight capacities, and illustrations of this hoist.—Louis E. Emerman & Co., 1761 Elston Ave., Chicago, Ill.

Electric Rivet Heaters—Catalog No. 26 describes and illustrates the Calorac line of electric rivet heaters.—Calorac Electric Corp., 52 Vanderbilt Ave., New York, N. Y.

Condulets—Catalog No. 2,100 describes the new Obround condulets with wedge-nut fastener. This 31-page publication contains illustrations of the numerous types of condulets with tables of sizes and prices.—Crouse-Hinds Co., Syracuse, N. Y.

Lighting Units—A 16-page illustrated booklet, No. 500, describes the Cooper-Hewitt, mercury vapor system of industrial plant lighting. Factors that must be taken into consideration in shop and room lighting are discussed at some length and tables are given showing the intensities produced by the lamps at various heights and distances. — Cooper-Hewitt Electric Co., Hoboken, N. J.

Volume 85 New York, July, 1927 Number 7

INDUSTRIAL ENGINEER

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Contents

Departments

"Kind Words"

IN THE New York office of INDUSTRIAL ENGINEER there is a big drawer of letters that have come in from men who read this paper. It is a vertical file and one of the guide cards is marked "Kind Words." Reach in and pull out a letter, and this is the kind of thing you read:

From a Pittsburgh manufacturer—

"You will be interested to know that we consider your publication the backbone of our industrial advertising. INDUSTRIAL ENGINEER has rendered a real service and as a manufacturer we believe your policy of getting to the actual operating men in the plants has made the work of our sales force more productive."

From a Galion, Ohio, operator—

"INDUSTRIAL ENGINEER has been of particular help to me in rewinding stators. I have also received a lot of valuable information on silent chain drives. I consider INDUSTRIAL ENGINEER the most valuable trade paper that I have ever read, and I have filed away a copy of every number that has been issued."

And so they run. You could read all day. And as you read you get the picture. For after all INDUSTRIAL ENGINEER is not just the printed paper that you hold in your hand. It is the voice of many men talking among the factories; talking month by month about their problems and experiences in operating and maintaining American industry. And listening to this voice, waiting for each message, are these thousands upon thousands of practical men—in towns and cities scattered across the map—who keep the wheels turning that production may flow on.

This magazine is the bond of communication that enables them to help each other. "Kind words" from them are worth the winning.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

WASHINGTON, Colorado Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4
Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

NEW YORK District Office, 285 Madison Ave.
Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record — American Machinist
Power — Chemical and Metallurgical Engineering
Coal Age — Engineering and Mining Journal
Ingeniería Internacional — Electrical Merchandising
Bus Transportation — Electric Railway Journal
Electrical World — Construction Methods
Industrial Engineer — Radio Retailing
Electrical West
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3 1879

Volume 85 New York, August, 1927 *Number* 8

G. A. VAN BRUNT
Editor
D. H. BRAYMER
Consulting Editor

INDUSTRIAL ENGINEER

Founded in 1888 as Electrical Review with which was consolidated Western Electrician

A. J. WHITCOMB
Contributing Editor
F. E. GOODING
G. H. FAIRBANKS
Associate Editors

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Contents

Departments

Keeping Up to the Minute

OPERATING men in industrial plants that are located close to large cities are fortunate in having an opportunity to visit different plants and keep in touch with the progress that other men engaged in similar lines are making. They can discuss problems of mutual interest, and find such contacts both stimulating and helpful. However, many plants are located in isolated communities, so that frequent visits to other plants are impracticable.

Although remote from industrial centers, in point of distance, operating men in such plants are not isolated and dependent on their own resources. Once a month INDUSTRIAL ENGINEER brings to them the written record of how other men have solved puzzling problems, details of their experience in meeting the emergencies that are constantly arising in plant operation, helpful short-cuts, the latest information about new equipment that has been designed to solve operating problems and cut costs—in brief, all of the information that the plant man will find useful in his work.

"INDUSTRIAL ENGINEER has been worth more to me," a man who is handling a big job in an isolated plant said the other day, "than any other magazine that I have ever taken or had anything to do with in any way."

Thus do thousands of operating men in plants all over the country look to INDUSTRIAL ENGINEER for the solution of many of their problems and to keep their information on approved methods and good operating practice up to the minute.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

WASHINGTON, Colorado Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4
Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

NEW YORK District Office, 285 Madison Ave.
Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record — American Machinist
Power — Chemical and Metallurgical Engineering
Coal Age — Engineering and Mining Journal
Ingeniería Internacional — Electrical Merchandising
Bus Transportation — Electric Railway Journal
Electrical World — Construction Methods
Industrial Engineer — Radio Retailing
Electrical West
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3 1879

A direct personal question:

How is electrical equipment operating in your plant?

Are you troubled with faulty commutation?

Do your brushes give long life?

Are your machines being destroyed by brushes which cut the commutator?

Which is better—to save the cost of new brushes or spend many times their cost for a new machine?

Boxill-Bruel Carbon Co. and B-B Brushes are doing much to eliminate these uncertainties. Remarkable uniformity is maintained in grades of B-B (Boxill-Bruel) Carbon Brushes in resistance, hardness and mechanical strength.

But with all this care in manufacture, nothing is taken for granted. *B-B Brushes are tested to determine the actual characteristics* of their various compositions. Boxill-Bruel know just what B-B Brushes will do in service. The customer is not asked to experiment at his expense when he equips with B-B Brushes.

Why not take advantage of the opportunity offered in B-B Brushes for low cost commutation and better, longer service.

These engineers' helps waiting for you—check.

BOXILL-BRUEL CARBON CO.

Cincinnati, Ohio

Please Send Me—

- ☐ Engineering Data Sheets.
- ☐ Code Sheets.
- ☐ Compilation Sheets—Correct Boxill-Bruel Brush for Each Class Machine.
- ☐ General Catalog.

NAME ....

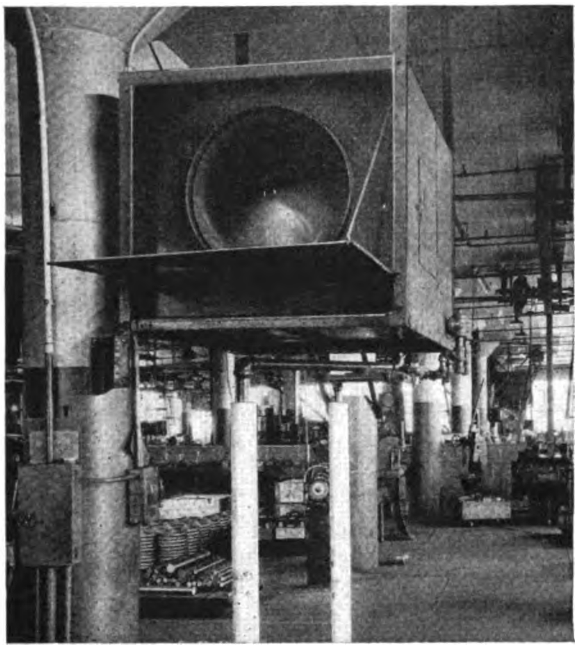
FIRM ....

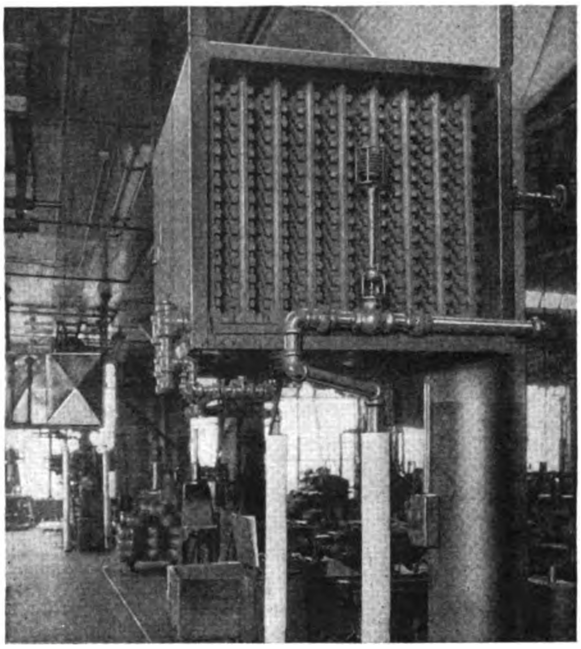
ADDRESS ....

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 85 New York, August, 1927 *Number 8*





Each of these Ilg unit heaters is controlled through the Powers thermostat regulator on the inlet end of the cast-iron radiators, in the illustration at the right. The temperature of the incoming air thus regulates the amount of steam supplied to the radiators.

Applications of Unit Heaters in Industrial Plants

By FRANK E. GOODING
Associate Editor, Industrial Engineer

MAKING adequate and economical provision for heating the industrial plant, particularly in sections where men and women are employed, requires careful study and observation on the part of the executive who is responsible for this service. Correct heating means more than the computation of the heat losses and a determination of the number and size of radiating or heating elements capable of providing the necessary heat. Many plants with ample provision for heating are not comfortable, however, and do not afford good working conditions because the arrangement of the heating elements or units is not such that the heat is placed or used properly; some parts of the plant have too much heat, while others do not have enough.

Heat is necessary for comfortable operation and must be supplied at varying temperatures depending upon the type of work done. For example, women workers seated at light assembly tasks require the maintaining of slightly higher temperatures than where men are engaged in heavy and active work.

Industrial plant heating is usually accomplished by one of the following three methods, and commonly with the use of steam as the original source of heat. These methods are:

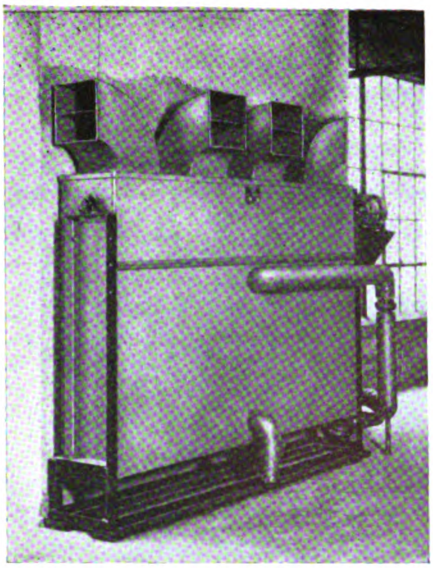
(1) Direct radiation by steam coils or radiators usually located along the walls or on the ceiling.

(2) Hot-air duct system with central steam coils, fans, and ducts to distribute the heated air.

(3) Unit heaters of various types, a complete installation for a plant or room consisting of a number of units each containing a fan and a source of heat.

As stated, radiators or steam coils for direct radiation are usually placed along the walls or on the ceiling and depend upon natural circulation due to the heated air, which has been in contact with the surface of the coil or radiator, rising and the colder air at the floor level replacing it. Frequently, this results in a hot, upper level of air and a cold floor level.

An open window or skylight or a draft caused by open doors or stairways will usually prevent the functioning of natural circulation. This makes direct radiation more difficult to control especially on mild days in the spring and fall when windows are



Floor-mounted unit heater with four outlets or diffusers.

Each outlet is supplied from an individual fan mounted on a long shaft and driven by the motor at the right. Cold air enters these York heaters at the floor level and is drawn through a high-pressure steam coil.

likely to be opened. In such cases the heat goes out of doors and the rapid circulation of cold air around the radiators results in the very uneconomical use of steam. It is not at all uncommon for heating, in such cases, to cost more during mild weather than in cold weather.

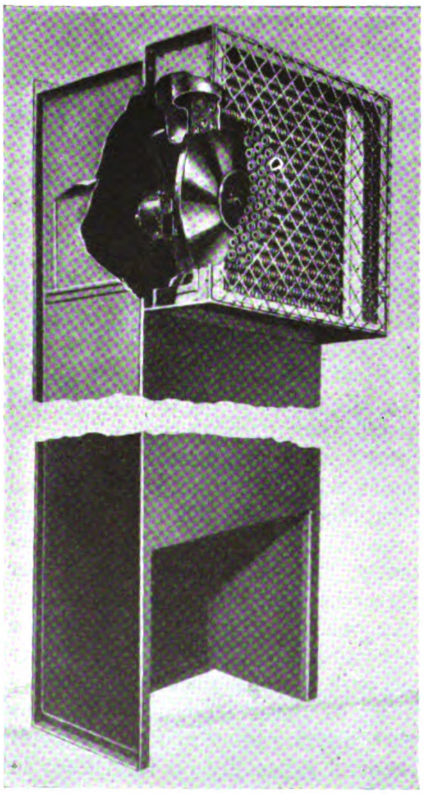
Heat regulators are used sometimes in connection with direct radiation to shut off the steam supply, but they are most successful in smaller rooms where the heat is likely to be more uniform throughout, and fewer radiators are to be controlled by each heat regulator than in the large area of the workroom in the average industrial plant.

The use of a central heating unit, consisting essentially of a fan, steam radiators, and a system of sheet-metal ducts for distributing the heated air to various parts of the room or building, is also widely used in industrial heating. Such a system is usually tied in with the ventilation and is possibly necessary where it is desired to provide air of any special humidity or to wash and clean the air before using or recirculating. In such cases air washing and conditioning equipment is added to the system as previously mentioned.

One of the advantages of this method of heating is that the heated air is delivered where it is wanted. Thermostatic control placed in the inlet or outlet of the heating and conditioning equipment regulates the temperature of the outlet air by controlling the steam supply. Open windows, drafts, or strong side-winds affect the distribution of the heated air. The effect, however, is not so pronounced as when direct radiation from steam coils or radiators is used.

Frequently, due to changing conditions in industrial plants it is necessary to move heating ducts and rearrange them to accommodate even minor changes in machine layouts. In case the duct line is not located properly and does not distribute the air where it should go, it is often inconvenient and expensive to change it. Also, where overhead cranes are installed it is sometimes difficult to find a place to locate the ducts and it may be necessary to run them underneath the floor. A decided advantage of the duct system, however, is that it can be used to distribute cooled air through the building in summertime.

In buildings which were inadequately heated in the days when industrial heating equipment was not so scientifically designed, it had become the practice, in many cases, to install a number of open salamanders, usually burning coke or charcoal, in the cold spots. These were very undesirable not only on account of the smoke and gases but more particularly because of the fire hazard. In addition, this was a very inefficient means of heating, and did not in any way distribute the heat except by the natural drafts in the room.



Floor-mounted unit heater with recirculating box.

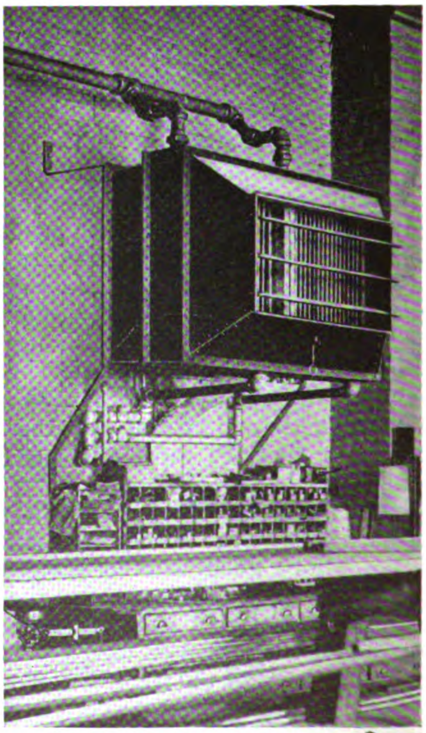
The cut-away view of this ABC Venturi unit heater shows the construction of the high radiating, copper coils with extended fin surfaces. The recirculating box is used to draw the air from the floor and to give more complete circulation.

Modine Thermodine unit heater.

The condenser consists of a large number of flattened, vertical copper tubes rigidly held in position by a series of horizontal copper fins spaced and constructed so as to cause the air passing through to come in contact with the heat-radiating surfaces.

Units should be mounted at least 20 to 30 in. from a wall.

This provides space for the circulation of the air to the inlet side of the heater. When wall-mounted, dual outlets are sometimes used to give wider distribution. This is an Autovent installation.



Here the heater is mounted on the platform and discharges heated air downward and away from the saw-tooth roof

This shows one of 16 Skinner Bros. Inverted-type, steam coil heaters for ceiling mounting in one of the plants of the Westinghouse Electric and Mfg. Co.

The need for suitable heating equipment in the many buildings in which it was necessary to distribute a few such makeshift heating units around the floor, even though the walls were all provided with coils or radiators, led to the development of unit heaters.

A unit heater consists essentially of a fan and a source of heat. The principle involved is that, instead of having a large central heating unit with a system of ducts distributing the heated air to various points of the building before discharging into the room, a number of small units, each with its own heating unit and fan to distribute the air, are located at suitable points in the room. One of the big advantages of unit heaters lies in the elimination of the ducts, and so the unit does not require a large amount of power as is necessary for forcing the air through the ducts.

In general, unit heaters fall into some of the following classes: (*a*) The direct-fired type which may best be described as a pipeless hot-air furnace with a fan to circulate the air and distribute it about the room. (*b*) A system which includes a few large units with fan and steam or hot-water coils. (*c*) A number of small units, each with its fan and steam coil.

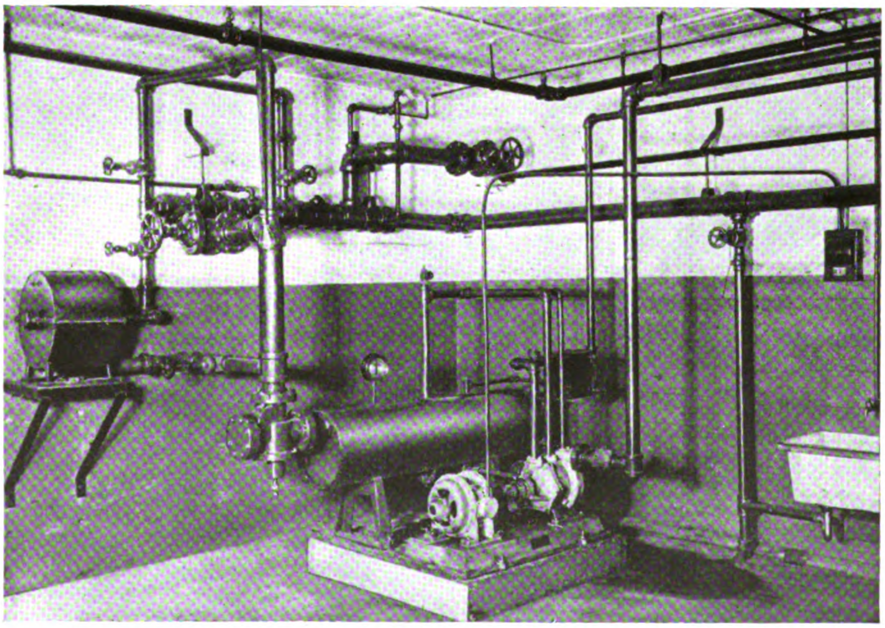
Steam is the medium commonly used for heating the air, although hot water is sometimes used. Also, in the types of direct-fired hot-air heaters mentioned, the heat is obtained from a fire, usually of coke, although the fire hazard has prevented this type of unit heater from gaining wide popularity. These units are used where there is no steam supply.

Direct-fired units are always floor-mounted. A number of the other types and makes of unit heaters are designed either to be mounted on the floor or suspended from the ceiling. Floor mounting is usually satisfactory where the ceiling is not over 15 ft. in height. When the ceiling is higher, and with monitor or sawtooth roof construction, it is often advisable to mount the heater on the ceiling. Ceiling mounting also conserves floor space.

In some cases the floor unit and the ceiling-mounted unit are almost identical except for the method of support, which usually consists of angle-iron legs either extending down to the floor or up to the ceiling.

Because a unit is designated as floor-mounted it does not mean, however, that the heat is distributed at or near the floor. The heat should always be discharged above the level of the men's heads. The large floor-mounted units extend down to the floor. Sometimes the smaller units are provided with a floor intake or recirculating duct, as is shown in one of the illustrations on page 350. These recirculating ducts are used to draw the air directly from the floor and recirculate it instead of taking it in on a level with the discharged air, as is the case when no recirculating duct is used. Where the floor is very dusty, for example, it is generally better to withdraw the air for recirculation from the level of the fan than from near the floor. Sometimes duct connections are made to the outside instead of recirculating the air from within the room.

Some manufacturers recommend the use of recirculating boxes only where there is considerable height to the building to be heated, or where men are working at benches and are not in motion. There is a small differ-



Vacuum equipment for a battery of unit heaters

This Jennings Hytor vacuum heating pump (Nash Engineering Co., South Norwalk, Conn.) is connected on the steam return lines at the Ilg Electric Ventilating Co., Chicago, Ill., where the units illustrated at the beginning of this article are installed. The condensate is measured in the Detroit meter at the left (Central Station Steam Co., Detroit, Mich.) so that the amount of steam used for heating is known at all times. Steam is generated in oil-fired, low-pressure boilers.

This unit heater has an outside inlet

This Buffalo Breeze-Fin unit heater is arranged to draw air from the outside or to recirculate from the inside, as desired. Sometimes overhead units are provided with ducts extending to the floor for recirculation.

ence, it is said, between the temperature at the ceiling and floor, because the lower strata of air are kept in circulation, when return air connections such as these recirculating boxes are used. In some instances recirculating connections are also justified as a means of supporting the unit. Frequently it is necessary to mount the unit on a wall and something in the form of a platform or support must be used; these recirculating connections also serve this purpose. In some cases duct or recirculating connections are used with ceiling-mounted units as well.

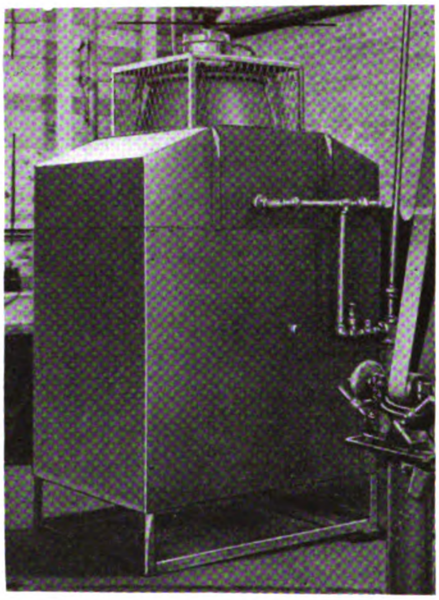
Practically all manufacturers of unit heaters provide units which contain either cast-iron or steel-pipe coil radiators or coils made up of special tubes with expanded fins such as the Aerofin, giving an extended surface with high-radiating capacity although light and strong. The coils are offset or staggered to prevent the air from having too easy or free a path past the radiating surfaces. Ordinarily radiators and the special finned coils are used with low-pressure steam. One type of special finned coil may be used with steam pressures up to 150 lb. per sq.in., it is said. For high-pressure steam, coils of steel pipe or high-pressure radiators are used. However, a very large proportion of industrial heating systems use low-pressure steam. Units with the cast-iron radiators are larger than units of similar rating with coils of finned construction and high radiating capacity.

Examination of the various types of unit heaters illustrated in this article will indicate a rather wide use of the propeller type of fan, although some units use the multiblade blower type or other types of fans.

Propeller fans and the small

Unit heaters do not occupy much space

Here these Buffalo unit heaters are mounted on the building columns in between two crane runways. These are turbine-driven units using the exhaust from the turbine to heat the air.

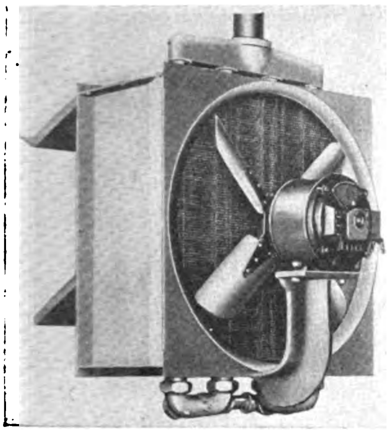


This unit heater discharges heated air horizontally in all directions

The fan at the top of this new Clarage floor-mounted heater is mounted with the shaft vertical instead of horizontal, as in many of the other types of unit heaters. A companion Clarage unit, inverted, however, is used for mounting on the ceiling. Special copper radiating coils are used.

Two installations of heaters in the Schenectady works of the General Electric Co.

These heaters were built by the L. J. Wing Mfg. Co. Only ceiling-mounted and horizontal-type unit heaters are built by this organization. Notice in these two illustrations the difference in the direction of the diffusers on account of one being built for a low ceiling to give a wide angle of distribution and the other, in the peak of the ceiling, with a sharp angle downward.



Unit heater with wedge core radiator

This Buffalo Breeze-Fin unit heater is a special, extended-surface, high-radiating-capacity unit. The steam section of the radiator is wedge-shaped with aluminum fins extending at right angles and held in metal-to-metal contact by springs. This unit, it is said, can be used with steam up to 150-lb. pressure.

blowers used require a comparatively small amount of power to operate and in the case of several manufacturers, the largest unit made requires a 1-hp. motor or smaller. The smaller sizes of unit heaters are frequently operated from the lighting circuit.

With propeller-type fans it is necessary to pass the air alongside the motor, in that the fans are direct connected. With some makes of unit heaters the propeller fan is on the inlet so that the cooler air passes the motor. In other types the propeller fan is placed on the outlet where the motor is exposed to the direct heat of the air. In such cases special provision must be made for ventilating the motor, to keep it cool. Where blowers are used the motor is not in the line of circulation.

Where it is necessary to place a unit heater in such a position that men are working in front of it, it is necessary to use deflectors or louvres to carry the heated air above their heads. In other cases it is advisable to use these deflectors so as to send the air down, as for example in case of a high ceiling. By constructing special outlets, as shown in several of the illustrations, it is possible to divide the discharge so that it will go in more than one direction. This arrangement is frequently used where it is necessary to place the unit alongside one wall or near the end or short side of a building and depend on it to heat that entire end or side.

Unit heaters, the same as any other type of heating equipment, are designed to overcome the heat loss computed on a B.t.u. basis. These computations take in the amount of glass and other wall, ceiling, or roof area, and other sources of radiation and heat loss. The method of computation is too detailed to explain here but is given in any handbook covering heating. However, the size and shape of the room, type of construction, type of windows, and other special factors influence the rating, type, number, and location of the various units to such an extent that it is advisable to consult with the manufacturer of the unit and obtain his recommendations on these points before making an installation.

The return line of the steam condensate may either be coupled to an atmospheric return through a trap or to a vacuum system. Because plants should know their cost of operation it is well to meter or measure in some way the condensate so as to know the cost of heating. This is not always done but without some knowledge of the total cost, and of the comparative cost over a period, expensive losses may occur for some time without being discovered.

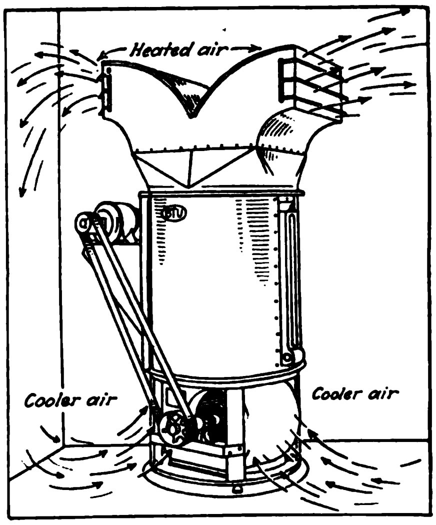
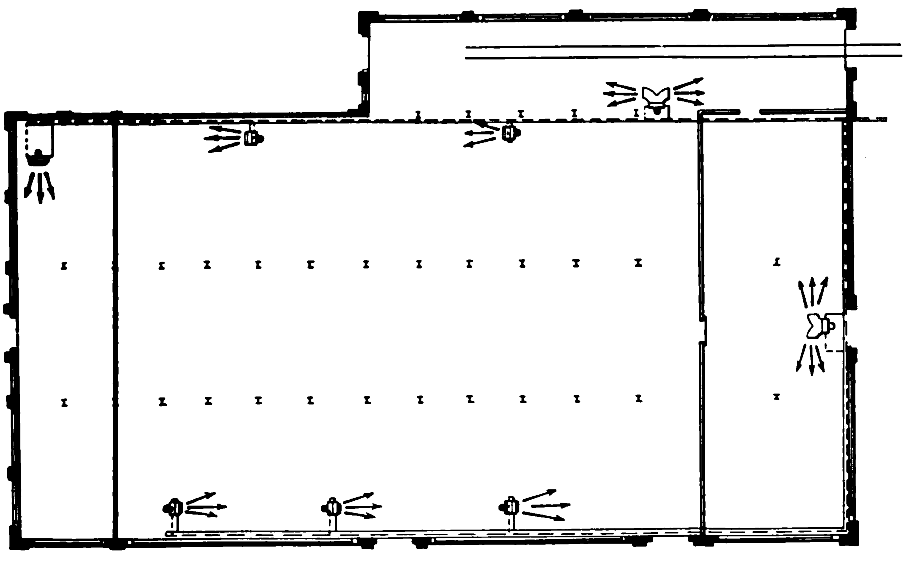


Diagram of operation of the Boyley Thermo Unit

This unit uses a multiblade fan belted to a motor. Inverted units are used for high ceilings.



Suggested arrangement of unit heaters

Notice that special care is taken to force the heated air into the exposed corners at the right end. If this plant had an extra-high ceiling or was much wider, additional units might be necessary in the center.

One of the best methods of controlling the cost of heating is through the use of some method of thermostatic control which operates or shuts off the unit according to the temperature. Thermostatic control units may be obtained either to control the power circuit to the fan or to close or open the steam line. A Powers regulator for controlling the steam line is shown in the illustration at the right at the beginning of this article on page 349.

The regulator shown is placed about 6 in. away from the radiator at the inlet end of an Ilg unit heater. With the air in forced circulation the radiator does not affect the regulator even at this short distance. The temperature of the air in the room as it passes the regulator operates the diaphragm which opens or closes the steam line to the radiator. Thus the temperature of the air in the room controls the amount of steam supplied to heat the air as it passes through the heater.

In the plant in which this photograph was taken the thermostat is set to operate at an inlet temperature of about 68 deg. F. The temperature of this inlet air is naturally the temperature of the room. In case the power to the fan should be shut off for any reason the circulation would

(Please turn to page 374)

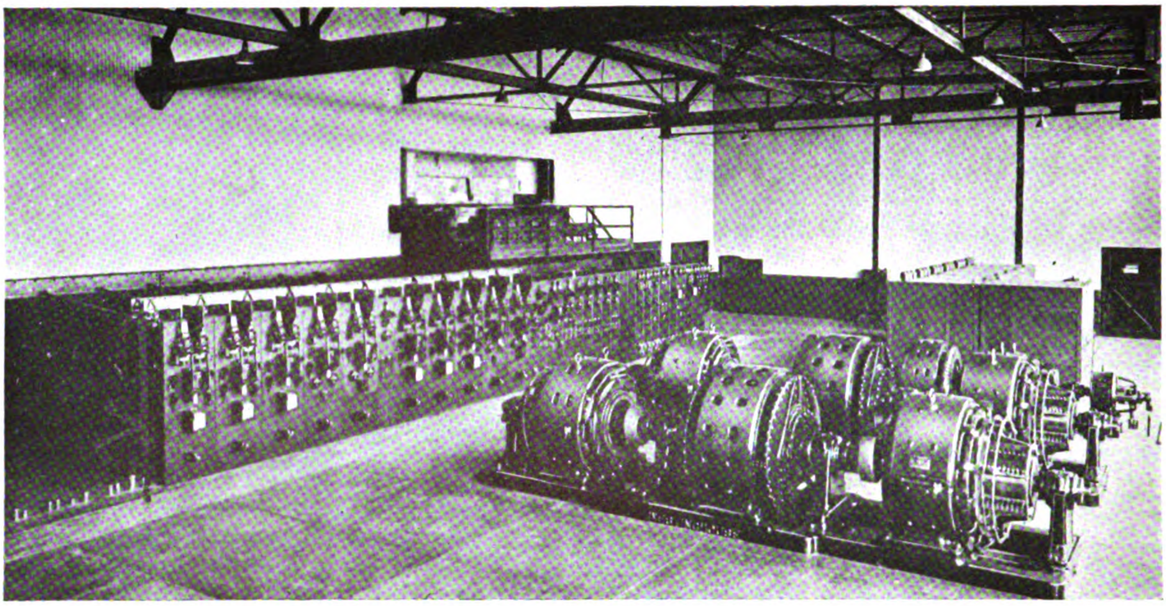


Fig. 1—An installation of truck-type, electrically operated circuit breakers for controlling the a.c. motors in a large steel mill.

Operating Advantages of

Truck-Type Switchboards

By F. M. BILLHIMER
General Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

THE ability of modern generating stations and substations to give dependable service is the result of much care in the selection of equipment best suited to the service. Furthermore, the individual pieces of equipment must be kept in first-class operating condition at all times, in order to insure continuous service. This means that the design and installation must be such as to allow ready inspection and prompt substitution of spare equipment in case that which is in service is damaged by abnormal system conditions.

Although there are many different pieces of equipment which contribute to the satisfactory performance of a generating station or a substation as a whole, it is desired at this time to describe and point out briefly the possibilities of an important item of equipment—the truck-type switchboard, several units of which are shown in Fig. 1, above. This type of switchboard usually consists of standard oil circuit breakers, relays, meters and instrument transformers mounted on a suitable structure that is fitted with wheels. This structure or truck fits into a self-supporting sheet-steel housing.

Truck-type switchboards, in general, are built for the same kinds of service as other switchboards and are designed to carry the same switching and other equipment that has heretofore ordinarily been mounted on stationary structures. These boards are made of metal, whereas the use of masonry was previously more common. Standard apparatus is used throughout on such switchboards, which in their completed form afford unusual features for safety to life and property.

Although truck-type switchboards are usually of the indoor type, their application is not limited to indoor use. For example, a truck unit for indoor service can also be used in an outdoor switchhouse that has been especially constructed with rails, disconnecting contacts and other necessary details for receiving the truck. The foundation can be arranged so that the removable unit can be rolled directly into an automobile truck and transported to the shop for repair or inspection.

The truck is equipped with contacts for conducting the main line current to and from the circuit breaker and the inclosing housing. In addition to these large contacts, which serve as disconnecting switches, other contacts of lighter construction are supplied for the metering and control circuits. Typical primary contacts are shown in Fig. 2.

Truck-type equipments are particularly adaptable for industrial plants on account of their safety features. All high-voltage parts are inclosed to protect the switchboard attendant from coming in contact with them. The framework of the housing and the truck is grounded. The equipment itself is thoroughly interlocked to prevent mistakes in operation that might cause injury to the operator.

Safety is assured the switchboard attendant, as all live, high-voltage parts are isolated and the equipment is thoroughly interlocked to prevent the circuit breaker from being inserted into or removed from the housing until the breaker is in the open position. When the circuit breaker has been removed from the housing, all high-voltage buses and contacts are automatically covered by shutters which prevent accidental contact with these parts.

The duties of maintenance and inspection may be safely carried out, as the truck containing the circuit breaker, operating mechanism, instrument transformers, meters and relays can be taken out of service, as shown in Fig. 3, by simply removing

it from the housing, thus disconnecting all parts from the circuit.

In addition to insuring safety for the attendant and providing protection and switching facilities equal to those afforded by standard, stationary circuit breakers and other equipment mounted on a structural or pipe framework or in masonry cell structures, the truck-type switchboard has a number of other inherent advantages.

For example, it provides a double set of simultaneously operated disconnecting switches interlocked with the breaker. The primary contacts isolate both sides of the breaker when the truck is withdrawn. As in the case of breakers in stationary structures, truck breaker operation may be checked when isolated from the busbars, as the secondary contacts are not opened in the disconnected or partially removed position of the truck.

Low maintenance cost is possible because repairs may be made at the time and place that are most convenient. A spare truck may be used while another truck is being inspected or repaired.

Unity of responsibility is assured with this type of equipment. This responsibility rests with the manufacturer, as he builds the equipment, assembles, tests and inspects it before shipping it to the purchaser.

Service interruptions are of short duration, as the operator can insert a spare truck should this be necessary. All trucks of like type and rating are usually made interchangeable between housings.

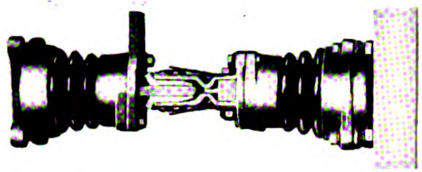


Fig. 2—Details of primary contacts used on truck-type switchboards.

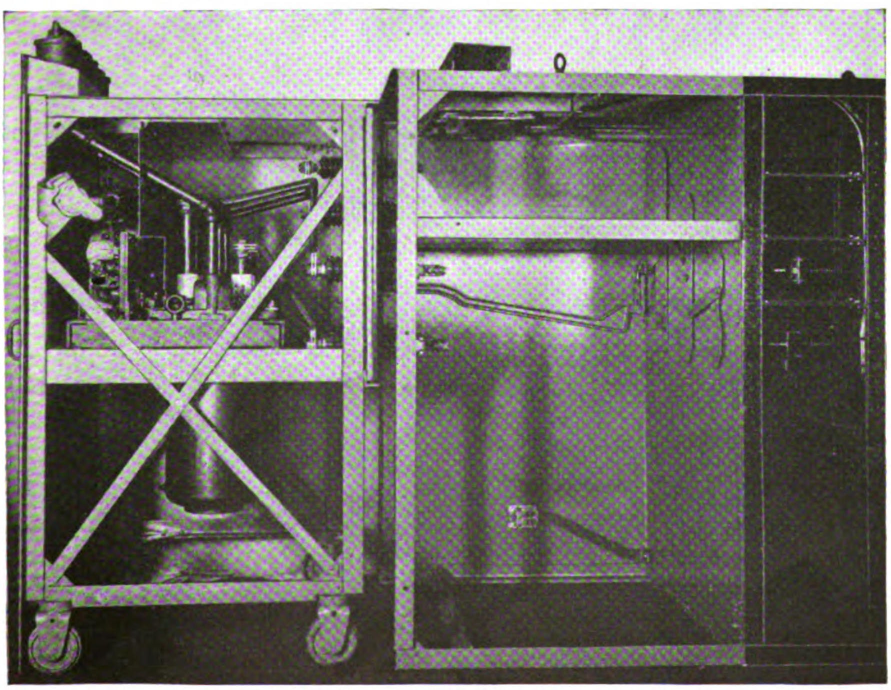
The height of the building that houses the equipment can be reduced to a minimum, as there are no vertically mounted disconnecting switches, and the space required for tank removal can be eliminated if an inspection pit is used for that purpose. Floor space can also be saved, as no aisle is required behind the ordinary truck-type switchboard.

Installation cost is low, as the purchaser does not assemble and mount the various pieces of equipment. He simply places the housing at the desired location, connects the primary cables and the secondary control wiring at the proper location in the housing, and then pushes the truck into the housing. Due to this small amount of work to be performed, an extremely short period of time is required for installation.

The housing is a unit portion of the structure which is made separate from the other parts for convenience in manufacture, installation, and operation. Housings are usually occupied by fixed equipment. They may, however, be occupied by movable equipment or by a combination of fixed and movable equipment.

Fig. 3—Truck-type, 1200 amp. circuit breaker and housing for 6,600-volt steel mill service.

This illustration shows the housing with the sheet-iron sides removed. The truck is in the totally disconnected position. The bus insulators and stationary contacts may be seen at the right, in the rear of the automatic shutters.



Housings are built of structural steel members joined by cast corner pieces—all bolted together to form extremely rugged structures which will not be distorted during shipment or when inserting or withdrawing the trucks. Sheet steel is used for covering the housings. Guide extensions are provided at the forward end of the rails to center the truck as it enters the housing. The rails are drilled for foundation bolts, and the uprights are provided with holes for bolts between adjacent housings. The sides adjacent to bus compartments are removable to allow for extensions and for the installation of the busbars. Access to busbar supports, primary contacts, cable terminals and the like is provided by removable plates.

The superstructure of a truck-type switchboard is the upper portion of the housing over the truck compartment and may be occupied by busbars, disconnecting switches, or voltage transformers.

The truck is a wheel-mounted framework of the same substantial construction as is employed for the housing and carries an oil circuit breaker, instrument transformers, relays, and instruments as required. The front panel is of smooth-finished sheet steel of sufficient thickness to give a rigid surface for mounting the apparatus. The truck is equipped with contacts for conducting the power between the truck and its inclosing housing. In addition to these larger contacts, other contacts of lighter design are supplied for the metering and control circuits. The trucks are equipped with wheels running on roller bearings. Fig. 4 shows the side and rear views of a truck carrying a Westinghouse Type B-13 circuit breaker. The construction of the truck and method of mounting the contacts and other parts are clearly shown in this illustration.

Truck-type switchboards are arranged so that the truck may be withdrawn a safe distance, clear of the live contacts, and latched there. In this position the primary contacts are open, whereas the secondary contacts are closed, providing a ready means of testing the instruments and the operation of the breaker.

The secondary disconnecting devices are self-aligning and remain in

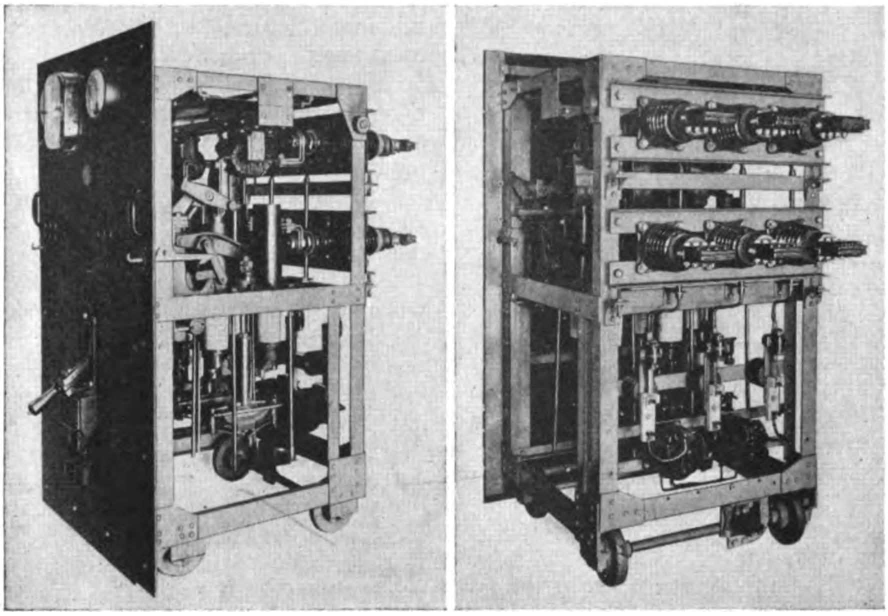


Fig. 4—Construction of the truck and method of mounting the contacts and other parts.

These are the side, at the left, and rear views of a truck carrying a Westinghouse Type B-13 circuit breaker. The contacts at the back of the truck engage with similar contacts at the rear of the housing when the truck is in the operating position.

contact when the truck is withdrawn to the disconnecting position in order that, the breakers and instruments may be tested for operation while isolated from the bus. The finger board on the truck is free to move horizontally and carries a guide pin at either end which engages with a fixed guide rail in the housing. This insures that the fingers will engage centrally on the contact shoes.

Automatic shutters, shown in Figs. 3 and 5, are provided for closing the opening at the rear of the housing through which the primary contacts pass. The shutters clear the opening for the live contacts as the truck is driven into the housing and close the opening again as the truck is withdrawn, thereby keeping the live equipment inclosed and isolated. The shutters can be blocked open for inspection purposes if desired.

As generally applied, interlocks make sure that none of the disconnecting devices between the trucks and the housings can be opened when carrying current or closed to establish current flow. The principal interlocks are mechanical and operate so as to require the circuit breaker to be open when the truck is being inserted or withdrawn from the cell. Electrical interlocks may also be used in combination with the mechanical interlocks.

The truck drive provides a positive lock in the operating position so that the truck cannot be moved except by means of a levering device. This gives additional insurance against the accidental disconnecting of the truck due to internal forces.

The field of application for truck-type switchboards is large, involving many classes of service. Steel mills, municipal plants, central-station companies and many industrial plants find this form of switchboard construction to be well adapted to the needs of their service.

The cost of truck-type boards will, of course, vary with the characteristics of the equipment, such as the interrupting capacity of the circuit breakers, the number of relays, meters, and the like. The cost of the completely assembled and tested equipment, as received by the purchaser, will naturally be more than for the same equipment unassembled and untested. Installation expense varies somewhat with local labor conditions. It is, however, a rather generally accepted fact that due to the small amount of installation work and testing required for the truck-type switchboard, the total cost of equipment, installation and testing is approximately the same as for the type which is purchased unassembled. In addition, the features mentioned above as distinct advantages are secured at very little, if any, extra cost to the purchaser.

Fig. 5—Automatic shutters at the rear of the truck housing prevent accidental contact with live parts.

One cell is shown with the shutters open and one with the shutters closed. The shutter-operating mechanism can be seen on the side walls of the cells. When the truck containing the circuit breaker is pushed into the cell, the lever is raised against the action of the tension spring by a suitable engaging member on the truck. The auxiliary contacts may be seen at the top of the cells; the grounding contacts are on the side walls at the bottom.

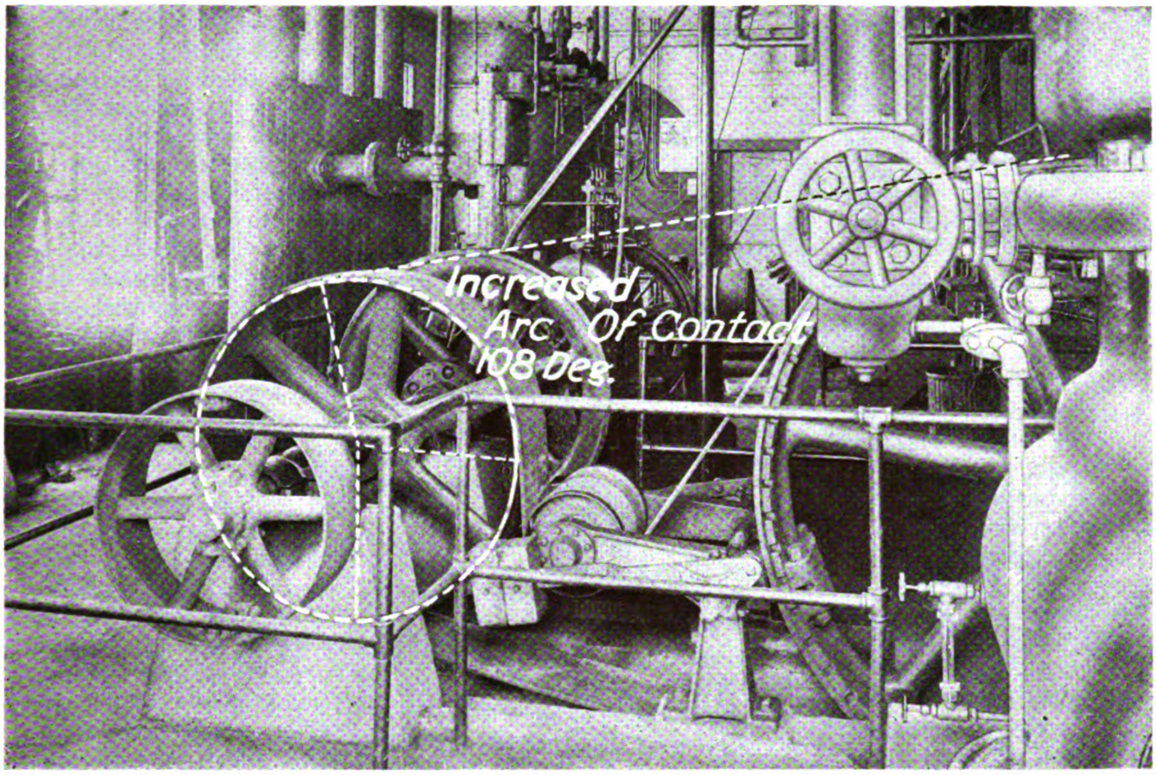


Fig. 1—Small pulleys do not have as much belt area in contact on open drives as when a flexible idler is used, as is shown by the dotted lines. This necessitates higher tension on the open drive to pull corresponding loads and as a result, a pulley approximately 25 per cent smaller can be used on flexible idler drives than would be required on open drives.

Influence of Pulley Diameter on Power Transmitted by Leather Belt Drives

By ROY C. MOORE
Chief Engineer, Chas. A. Schieren Co., New York, N. Y.

PREVIOUS articles* in this series on leather belt operating practices which have already appeared in INDUSTRIAL ENGINEER have discussed the importance of having a proper center distance on open belt drives and the use of fixed or flexible idlers where shorter center distances were desirable or necessary. Another point, which also has an important effect on belt life and operating difficulties or freedom from troubles, is the diameter of the smaller pulley.

The ratio of speed reduction in any installation is determined by the relative speeds of the driving and driven shafts. This ratio on any particular drive is usually fixed very definitely and can seldom be changed much, if any, without creating an entirely new operating condition.

Because the cost of the two pulleys increases with the diameters it is less expensive from the standpoint of installation first cost to use as small a pulley as possible on the first reduction. This is particularly important with high-speed motors because, even in ordinary drives, reductions of 6:1 or even more are quite common. This would necessitate a large pulley with a diameter six or more times as great as the smaller pulley. Thus each inch saved in the diameter of the smaller pulley has a multiple saving in the diameter and cost of the larger pulley.

There is a minimum diameter, however, below which it is inadvisable to go because of the effect of the decreased surface in contact and shortness of bend, as will be explained later in this article, on the belt as it passes around the small pulley. Before continuing further it may be well to emphasize that the rules for belt thickness as regards minimum pulley diameters are just as applicable to the idler pulley as to the driver or driven pulley, whichever is the smaller.

The lack of suitable data in any of the standard engineering handbooks on the minimum diameter of pulleys suitable for given loads has been the cause of many short-lived belts, as well as an endless amount of trans-

*NOTE—The first article of this series entitled "Factors in Determining Proper Center Distances for Leather Belt Drives," appeared in the May issue, and the second, "Fixed and Flexible Idlers on Leather Belt Drives," in the July issue.

Figs. 2A and 2B—Relation of pressure to area of contact

When only the finger tips are resting on the desk, as at A, very high pressure must be applied to the small area in contact to prevent slipping. However, where the whole palm of the hand rests on the desk as in B, less pressure is necessary to prevent slipping. Similarly, to prevent slip where a small area of belt surface is in contact with the pulley a higher tension must be maintained than with a larger area of contact or wrap.

mission troubles. A better understanding of these troubles and their underlying causes will undoubtedly result in a better appreciation of what is required of the belt and pulley and the effect of neglecting these requirements upon satisfactory operation.

One of the first considerations is that the load, which is applied through the surface friction on the belt, must be distributed over a certain amount of pulley area for satisfactory operation. When the area of contact is too small the belt must be run excessively tight to increase the friction and obtain sufficient grip on the pulley. Also, since in such cases the friction between the belt and pulley is confined to a very small area there is a constant tendency to tear the surface of the belt. The result of operating under such conditions shows up quickly in the form of checks or cracks on the belt's surface. These cracks increase in size rapidly and soon grow into decided rents which indicate that the leather fibers are gradually being torn apart.

Insufficient contact area is also responsible for another trouble—friction burning. Friction burning is caused by the belt stretching, which reduces the pressure between the belt and the pulley surface to a point where the small area in contact can no longer adhere, and excessive slipping is the consequence. The friction created by such slippage soon burns the belt's surface. This condition is first indicated by a glazed appearance, and in many cases causes actual charring of the leather, especially if such a condition is permitted to continue for any length of time. Burned belts have lost many of their necessary physical qualities, particularly elasticity, and it is impossible to restore them to good condition. A slipping belt with a good surface (coefficient over 0.5) practically always identifies itself by a squeal, but if the surface is glazed or oily it may slip quietly and be noticeable only by the heat of the pulley face.

Anyone can realize more readily the value of area contact by performing the simple experiment of sliding the palm of the hand over the desk top and then trying to secure the same grip when applying an equal pressure by using only the point of one finger or even of all the fingers. Figs. 2A and 2B illustrate this point. When trying this simple experiment notice the greater pressure required to make the finger tip or tips grip as well as the palm of the hand or, with the same pressure, note the better grip of the palm as compared to the finger or fingers.

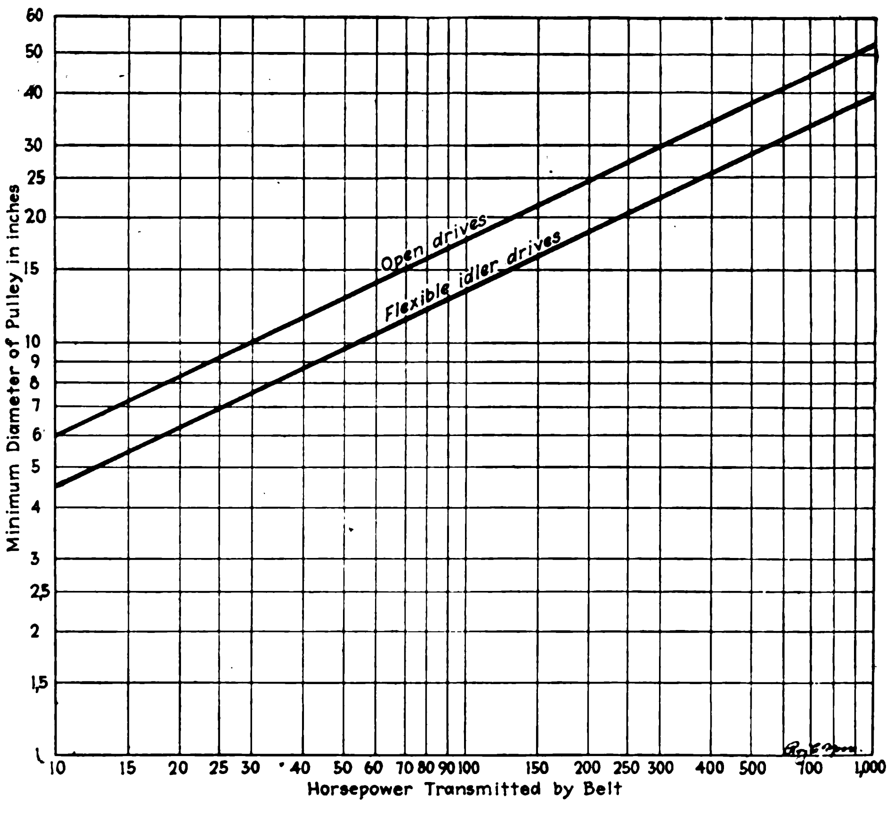
Because comparatively little data have been published on the effect of pulley diameter on belt life it was necessary to draw on practical operating data obtained from the history of a number of belts. In compiling a list of minimum diameter pulleys suitable for various loads, records of belts giving satisfactory service over a period of years, as well as drives where belts showed early failure, were carefully analyzed. First, all those cases were discarded where certain factors in regard to the drive showed the working strain to be either below or above a normal load for the belt.

Upon analysis of the remainder it was noted that in nearly all cases the belts did not have a satisfactory life when the pulley diameter was less than a given size. The writer, when compiling the information obtained from these records, found it convenient to plot on logarithmic cross-section paper, data as collected on drives which were failures as well as those which were successful.

The method of indicating was to mark circles at the diameter of the pulley for the load transmitted when successful, and crosses when not successful. In the course of time data were collected covering a range of drives with capacities from 5 hp. up to 1,500 hp. From these data a line or curve was drawn which placed nearly all the crosses which represented the failures, below, and the

Fig. 3—Curve showing relation between diameters of pulleys and horsepower loads transmitted by belts

Data obtained from a study of a large number of satisfactory and unsatisfactory belt drives were plotted on logarithmic cross-section paper. The straight line represents the average minimum pulley diameters which gave satisfactory results. The flexible idler drive permits the use of a pulley about 25 per cent smaller than required on an open drive to transmit equal horsepower. Fig. 4 shows the reason for this.



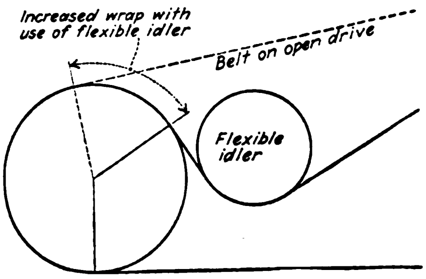


Fig. 4—This shows why a flexible idler drive will transmit more power than an open drive.

The flexible idler gives an additional belt wrap which increases the amount of belt surface in contact with the pulley. This permits the transmission of greater loads with the same size of driving pulley or the use of a smaller pulley (approximately 25 per cent smaller, as shown in Fig. 3) to transmit the same load. Any decrease in the size of the smaller pulley, as described in the text, permits a saving in first cost due to a correspondingly proportional decrease in the size of the larger pulley required to maintain the same ratio of reduction.

circles representing the satisfactory drives, above. Oddly enough, the curve, Fig. 3, proved to be a straight line when plotted on logarithmic paper.

A similar curve was plotted for the successful and unsuccessful drives using flexible idlers. (It must be appreciated that a flexible idler is not a cure-all. If the belt or pulley size is not correct or if the idler is improperly installed the drive is likely to cause as much trouble as similar improper conditions on an open drive.) When the data on the flexible idler drives were plotted it was found that the second curve, Fig. 3, was 25 per cent lower than the curve on open drives. This increased effectiveness of the smaller pulley was due to the greater wrap of the belt on the pulley as a result of using the idler. The amount of this increase in wrap is well shown by the sketch, Fig. 4. With the increase in wrap, it is not necessary to apply such a high tension or pull to get the same friction load on the larger surface. The area in contact increases in proportion to the increase in the amount of wrap.

Because of the difficulty of using the data on a curve of this sort when laying out drives the information in Table I was compiled for more ready reference. In this table fractions have been dropped and the nearest larger commercial sizes of pulleys in common use have been listed. These minimums, if religiously adhered to, will eliminate difficulties caused by pulleys that are too small for the load to be transmitted over them.

In using the pulley sizes listed in Table I, it is assumed that in each case a belt of the proper thickness and pliability will be used. It is desirable at all times when rather small pulleys are used to install the more pliable belts. Constant bending over small pulleys will soon break down the fibers in a stiff belt and shorten its life materially. A pliable belt bends much more easily and with no injury to its fibers.

It is generally conceded that oak-tanned belts (one type of vegetable tannage) are in general much longer lived than belts of special tannage. In looking over the outstanding records for long belt life, oak-tanned belts are in a large majority and practically predominate in all cases that have come to the attention of the writer. Special-tannage belts certainly have an important place in belt drives but the oak-tanned belt is usually to be preferred for general use on account of its much longer life and the fact that the total amount of stretch during its life is less.

Table I—Pulley Diameters for Horsepower Ratings

Horsepower	Minimum Diameter, Inches
10	6
20	8
30	10
40	11
50	13
75	16
100	18
150	21
200	24
250	27
300	30

NOTE—The normal ratings in the table are based on the use of pulleys no smaller in diameter than those given in the second column above. Where smaller diameter pulleys are to be used, complete operating data and a description of the drive should be submitted to the engineering department of the belt manufacturer, who will recommend the size and thickness of belt suited to the particular installation.

Although a pliable belt is usually more desirable than a stiff belt it will be found that the stiff belt is much superior on drives where the belt is subject to constant shifting because its edges will not crumple and break down so quickly as in the case of a pliable belt. Although pulley sizes are of extreme importance as regards the success or failure of the belt on the average drive, pliability and thickness of the belt are also very important factors.

The data given in Table II, which are commonly used by many belt men, may be of aid in determining whether the thickness of belt to be chosen will operate satisfactorily over the pulley. As a suggestion, it is well to give the details of any unusual drive to a belt manufacturer, and then follow his advice. This will assure the buyer of satisfactory belt operation under the conditions present in his plant.

Any departures made from the data given in Table II, such as allowing for wider pulleys and proportionately wider belts, are not to be recommended unless the plans for the drive in question are submitted to a belt manufacturer and approved by his engineering department before the belt is purchased.

The next article of this series, to appear in an early issue, will discuss the subject of belt speeds and their influence on the approximate costs of installation and operation.

Table II—Minimum Diameters of Pulleys Recommended for use with Leather Belts

Linear velocity of belt in feet per minute				1,000	2,000	3,000 and up
Width	**Ply**	**Weight**	**Thickness, In.**	**Pulley Diameter, In.**		
		Chrome	$\frac{5}{32}$	2	$2\frac{1}{2}$	3
Up to 8 in.	Single	*Light	$\frac{1}{8}$	2	$2\frac{1}{2}$	3
		*Medium	$\frac{5}{32}$	3	$3\frac{1}{2}$	4
		*Heavy	$\frac{3}{16}$	4	5	6
		Chrome	$\frac{5}{16}$	6	7	8
Up to 12 in.	Double	*Light	$\frac{1}{4}$	4	5	6
		*Medium	$\frac{5}{16}$	8	10	12
		*Heavy	$\frac{3}{8}$	10	13	14
Up to 24 in.	Triple	Chrome	$\frac{1}{2}$	18	24	36
		*Heavy	$\frac{9}{16}$	24	30	36

*Oak-tanned leather belts.

Requirements and Practices in

Wiring for Motor Installations

By GORDON FOX
Electrical Engineer, Freyn Engineering Co., Chicago, Ill.

THIS is the second article of a series of two, in which Mr. Fox discusses the Code requirements and recommended practices in installing conduit work and wiring for motor installation. The first article appeared in the July issue and dealt with the considerations involved in installing the motor control and protective devices, and in meeting the starting current limitations imposed by public utilities.

THE previous article on this subject, which appeared in the July issue, covered the considerations involved in motor installation, in so far as the motor, control, protective devices and starting current limitations were concerned. This article will deal with the Code requirements and recommended practice with respect to conduit work and wiring considerations.

The proper size of wire or cable to be used in connecting a motor is dependent upon several considerations. The minimum permissible size is fixed by the National Electrical Code, the requirements of which may be summarized as follows:

Conductors carrying the current of a single motor must have carrying capacity, according to the Code tables, of at least 110 per cent of the nameplate current rating of the motor.

Motors subject to peak loads (usually these are motors of varying speed and intermittent duty ratings) will require larger fuses or higher setting of circuit breakers than other motors. Therefore, the use of larger wires or cables is advisable. The carrying capacity recommended is from 110 to 250 per cent of the motor current rating, according to the service and the time basis upon which the motor is rated. The schedule for the determination of cable sizes for motors subject to peak loads is given in Table I.

For motors having large starting current, such as squirrel-cage induction motors and self-starting synchronous motors, it is required that

Table I—Summary of Code Rules for Motor Wiring and Cutouts

Capacity of Line

SMALLEST SIZE ALLOWED	BRANCH CIRCUIT SUPPLYING ANY MOTOR MUST HAVE CARRYING CAPACITY AT LEAST 110 PER CENT OF MOTOR RATING

LARGER SIZES RECOMMENDED IN SPECIAL CASES:

Motors Having Large Starting Current (Squirrel Cage, Etc.)		
Started with auto-starter		Started without auto-starter
Motor Rating 0-30 Amp.	Motor Rating About 30 Amp.	
250%*	200%*	300%*

*In that portion of motor circuit not protected by motor cutout

Motors Carrying Peak Loads	Percentage of Motor Rating				
Class of Service	5 Min Rating	10 and 15 Min Rating	30 and 60 Min. Rating	120 Min Rating	Continuous Rating
Operating valves, raising or lowering rolls	110	120	150	200	250
Rolling tables	110	120	135	180	200
Hoists, rolls, ore and coal handling machines	110	115	120	150	170
Elevators, shops, cranes, tool heads, pumps, etc	110	110	110	120	140

Line Cutout — LARGEST SIZE ALLOWED

Motors Having Large Starting Current		Motors Not Having Large Starting Current	
Fuse (R C Wire)	Circuit Breaker	Fuse	Circuit Breaker
Value in Table II, corresponding to capacity of line	130 per cent of capacity of line	Capacity of line	130 per cent of capacity of line

Motor Cutout

WHEN REQUIRED — For Each Continuous Rated Motor of Over 2 Hp. Used for Constant-Load Duty

Having large starting current	Not having large starting current
Motor cutout may be shunted or cut out of service while starting. Figure it independently of line cutout, as below	Motor cutout must be in circuit continuously. Usually make line cutout serve also as motor cutout by meeting the rule given below by using proper line capacity

LARGEST SIZE ALLOWED

Fuse (or thermal cutout)	125% of motor rating, except when none of required capacity exist, then use next higher standard rating
Circuit Breaker	Time limit: 125% of motor rating. Instantaneous: 160% of motor rating

For:
(1) Continuous rated motors of 2 horsepower or less; or
(2) Motors of other than continuous rating; or
(3) Motors used on other than constant-load duty

Line cutout is considered sufficient, if used

If there is no line cutout, a motor cutout is required

the wiring between the motor cutout and the line cutout be of such size as to be protected by the line cutout. The line cutout, in turn, must be large enough to carry the motor starting current without opening. In applying this rule it is generally assumed that the starting current will be:

250 per cent of rating for motors up to 30 amp. nameplate rating when started with auto-starters.

200 per cent of rating for motors above 30 amp. nameplate rating when started with auto-starters.

300 per cent of rating for all motors started without auto-starters.

In applying this rule, the current capacity of a given size cable as shown in column *C* of Table II may be used, even with rubber-covered cable. This special rule does not apply to the wiring between the motor cutout and the motor.

Table II lists the allowable current carrying capacities of copper wire and cable with the several classes of insulation, as specified by the Code.

Although the use of solid wire is allowed, it is the author's opinion that it should never be used for motor circuits of any importance, except that sizes from No. 8 B. & S. gage to about No. 0 may be used for the connections to resistors. No cables smaller than No. 12 B. & S. gage should be used for motor connections, nor for control pilot circuits. It is preferable not to go below No. 10 B. & S. gage. These small leads should always be of stranded cable. The likelihood of delays and damage because of breakage of small solid wires is out of all proportion to the small difference in cost. Above all, solid wires should never be used for the shunt field leads of a d.c. motor or for the field leads of a synchronous motor.

The wiring for magnetic control panels often involves a considerable number of pilot circuits. Multiple-conductor cable with identifying colors or tracers is helpful in this work. A drawback to its use is the need for several cables with different numbers of conductors. It is simpler to use several single-conductor cables with different colored braids or tracers and to combine these cables as required. A consistent color scheme should be used so far as possible. Where a number of leads are run in one conduit, it is sometimes worth while to include an extra cable as a spare. This may come in handy in case of failure of one of the cables or in case a change is made in the control such as to require another pilot circuit lead. If this is not done, it is sometimes a good plan to install conduits large enough to permit of an additional lead, should such become necessary. Where many small leads are pulled in one conduit, particular care is demanded to prevent injury to the insulation while pulling.

It is essential that the voltage be maintained at the motor terminals in accordance with the nameplate rating. Usually it is not good practice for the voltage drop in the wiring of an individual motor, back to the mains or distributing point, to exceed 1 to 2 per cent of the rated voltage when full-load current flows through the circuit. Cable sizes, as determined

Table II—Allowable Carrying Capacities of Copper Wire and Cable*

Size Cable B. & S. or A.W.G.	Area in Circ. M.	Diameter in Mils. Bare Str. Cable	Ohms Per M. Ft.	Current Capacity in Amperes		
				Class A	B	C
				Rubber	Varnished Cambric	Slow-Burning Weatherproof
16	2,583	58	3.936	6	...	10
14	4,107	73	2.475	15	18	20
12	6,530	92	1.557	20	25	25
10	10,380	116	0.979	25	30	30
8	16,510	145	0.6158	35	40	50
6	26,250	184	0.3872	50	60	70
5	33,100	206	0.3071	55	65	80
4	41,740	231	0.2436	70	85	90
3	52,630	260	0.1931	80	95	100
2	66,370	293	0.1532	90	110	125
1	83,690	332	0.1215	100	120	150
0	105,300	373	0.0963	125	150	200
00	133,100	419	0.0764	150	180	225
000	167,800	471	0.0606	175	210	275
0,000	211,600	528	0.0480	225	270	325
	250,000	575	0.0415	250	300	350
	300,000	630	0.0346	275	330	400
	350,000	680	0.0296	300	360	450
	400,000	727	0.0259	325	390	500
	500,000	815	0.0207	400	480	600
	600,000	892	0.0173	450	540	680
	750,000	997	0.0138	525	630	800
	1,000,000	1,152	0.0104	650	780	1,000

*Specified by the National Board of Fire Underwriters.

Table III—Cable Sizes for Continuous-rated D.C. Motors

DISTANCE IN FEET THAT STATED H.P. CAN BE TRANSMITTED WITH ONE VOLT LOSS

Note: This table is based on two leads to the motor.

					B. AND S. GAGE	10	8	6	5	4	3	2	1	0	00	000	0000
					SAFE CARRYING CAPACITY—AMP.	25	33	45	53	63	75	88	100	125	150	181	218
H.P. AT 115 VOLTS	H.P. AT 230 VOLTS	H.P. AT 500 VOLTS	FULL LOAD CURRENT AMP.	110% LOAD CURRENT AMP.	125% LOAD CURRENT AMP.												
		½	1.00	1.10	1.25	490	778	1232	1560	1920	2433	3122	3940	4928	6271	8907	9971
		1	2.00	2.20	2.50	245	389	616	780	960	1216	1561	1970	2464	3135	4453	4985
	½		2.30	2.52	2.87	213	348	535	680	834	1057	1357	1713	2142	2726	3872	4335
		2	4.00	4.40	5.00	122	194	308	390	480	608	780	985	1232	1567	2226	2492
½	1		4.50	4.95	5.62	108	173	273	346	426	540	700	875	1095	1395	1975	2215
		3	6.00	6.60	7.50	81	127	205	260	320	405	520	656	821	1045	1484	1661
		4	7.50	8.25	9.37	65	104	164	208	258	328	416	525	657	836	1187	1330
1	2		9.00	9.90	11.25	54	86	137	173	213	270	347	438	547	697	990	1108
		5	9.30	10.23	11.62	53	84	132	167	206	261	335	423	530	674	947	1072
	3	7½	12.50	13.80	15.62	40	61	100	125	153	194	250	315	394	501	712	798
		10	16.50	18.10	20.62	29	47	76	96	118	147	189	239	298	380	539	604
2	4		18.00	19.80	22.50	27	43	68	86	106	135	173	219	273	348	495	524
	5		21.10	23.20	26.37	23	37	58	77	91	115	146	186	233	297	442	472
3		15	25.00	27.50	31.25	20	30	50	62	76	97	125	157	197	250	356	399
	7½		28.20	31.02	35.25		27	43	55	68	86	110	140	174	222	315	353
		20	33.15	36.46	41.43		23	37	47	58	76	94	119	148	189	271	300
	10		37.60	41.36	47.00			32	41	51	64	83	104	131	164	236	265
5		25	42.00	46.20	52.50			29	38	45	58	73	93	116	143	211	236
		30	49.70	54.67	62.12				31	39	49	64	79	99	126	179	200
7½	15		56.50	62.15	70.62					34	43	55	70	87	111	157	176
		40	66.30	72.93	82.87						36	47	60	79	95	135	150
10	20		75.30	82.83	94.12						32	41	52	65	82	118	132
		50	82.80	91.08	103.50							37	47	59	75	107	120
	25		94.10	103.51	117.62								41	52	66	94	106
		60	99.40	109.34	124.25								39	49	63	89	100
15	30		113.00	124.30	141.25									43	55	78	88
		70	116.00	127.60	145.00									42	54	76	85
		80	132.00	145.20	176.00										47	67	74
20	40	90	150.00	165.00	187.50										41	59	66
		100	165.00	181.50	206.25											54	60
25	50		188.00	206.80	235.00											47	53
		120	198.00	217.80	247.50												50
30	60		226.00	248.60	282.50												44

Table IV—Cable Sizes for Three-Phase, 220-Volt Alternating-Current Motors

Horsepower	Full Load, Amp.	110 Per Cent of Full Load, Amp.	Cable Size	125 Per Cent of Full Load, Amp.	Cable Size	Starting Current: Per Cent Full Load, Current	Starting Current: Amp.	Cable Size, Code Basis
1	3.5	3.9	14	4.4	14	250	8.7	14
3	9.5	10.5	14	11.9	14	250	23.8	10
5	15.4	16.9	12	19.3	12	250	38.6	6
7.5	22.4	24.6	10	28.0	8	250	56	4
10	29.0	31.9	8	36.3	6	250	73	3
15	42.5	46.6	6	53	5	200	85	2
20	55	60.5	4	69	4	200	110	0
25	68	74.8	3	85	2	200	136	00
30	80	88.0	2	100	1	200	160	000
40	105	115	0	131	00	200	210	0,000
50	130	143	00	163	000	200	260	30,000
75	192	211	0,000	240	250,000	200	384	500,000
100	252	278	350,000	315	400,000	200	504	750,000
150	368	405	600,000	460	700,000	200	736	1,250,000
200	484	532	750,000	605	1,000,000	200	968	2,000,000

Use column 4 for circuit from controller to motor for squirrel-cage and synchronous motor and for the entire circuit for wound-rotor motors.
Column 6 may be used for circuit ahead of controller for wound-rotor motors to permit larger line cutouts.
Use column 9 for circuit ahead of controller for squirrel-cage and self-starting synchronous motors.
Use next larger wire size throughout for motors whose speed is below 600 r.p.m.

by Code rules, should, therefore, be checked for voltage drop, particularly where the runs are at all long. With d.c. motors two or four leads must be considered, four being required with reversible, series and compound-wound motors. With three-phase a.c. motors the total drop is 1.73 times the drop in one lead.

Where conduits are buried and grouped or situated in warm locations, it is advisable to use liberal cable sizes in order to avoid temperatures which may hasten deterioration of the insulation.

Table III will be found useful for selecting cable size and checking the voltage drop of continuous-rated d.c. motors of any standard voltage. The table shows the full-load current, and the 110 and 125 per cent load currents of a range of motor sizes. These figures are based on conservative motor efficiency values and may differ slightly from actual nameplate ratings. The allowed safe capacity of various wire sizes is shown among the column headings. A wire size should be selected having a capacity of at least 110 per cent of the rated motor current. The length of circuit (two leads) which will cause 1 volt drop is shown. Greater distances cause proportionately greater voltage drop. Where four leads run to a series or compound-wound motor, the drop is double that shown. A ready check on voltage drop for any motor with any suitable cable and for any distance is easily and quickly obtained.

Table IV gives data for selecting sizes of cables for three-phase, 220-volt a.c. motors. Table V gives similar data for three-phase, 440-volt a.c. motors, and Table VI covers three-phase, 550-volt a.c. motors. The full-load current values given in column 2 are based on induction motors of moderate speed, which have fair efficiencies and rather low power factors. High-speed induction motors will have somewhat lower current ratings. Induction motors below 600 r.p.m. will have higher current ratings and will, in general, require one size larger cable. Synchronous motors operated at unity power factor will have lower current ratings, thereby permitting the use of smaller cables in some cases. These motors, however, are not always operated at unity power-factor, so a little leeway in cable size is permissible.

Cable sizes given in column 9 are based on the restriction of starting currents within the limits suggested by the Code and mentioned in a previous paragraph. Circuits connecting wound-rotor induction motors to their controllers need have but 110 per cent rated current capacity if the motor drives a steady load. A feeder circuit of 125 per cent capacity is frequently advisable between the controller and the mains to permit higher setting of the line protective devices. Column 6 is, therefore, included to show cable sizes based on 125 per cent rated current. When the motor is subjected to peak loads the entire circuit should be determined by the class and the basis of the motor rating, according to Table 1.

The Code requires that the line feeding the controller for a single motor be protected by fuses rated at the current capacity of the line (column A, Table II) or by a circuit breaker which may be set up to 130 per cent of the current rating of the line. An exception is made in the case of a line feeding a squirrel-cage induction motor or a self-starting synchronous motor in that the current capacity of the line cables is then figured on the basis of column C, Table II, thus permitting slightly higher fusing or setting of circuit breakers.

The Code requires that a switch or a circuit breaker be installed to open all the lines feeding a motor; thus a three-pole switch or breaker is required for three-phase motors and a four-pole switch or breaker is required for two-phase motors. This switch or breaker must always be installed when an auto-starter or oil-immersed starting device is used, due to the oil hazard. With other types

Table V—Cable Sizes for Three-Phase, 440-Volt Alternating-Current Motors

Horsepower	Full Load, Amp.	110 Per Cent of Full Load, Amp.	Cable Size	125 Per Cent of Full Load, Amp.	Cable Size	Starting Current: Per Cent Full Load Current	Starting Current: Current, Amp.	Cable Size, Code Basis
1	1.8	2.0	14	2.3	14	250	4.5	14
3	4.8	5.3	14	6.0	14	250	12.0	14
5	7.8	8.6	14	9.8	14	250	19.5	12
7.5	11	12.1	14	13.8	14	250	27.5	8
10	15	16.5	12	18.8	12	250	37.5	6
15	21	23	10	26	8	250	52	5
20	27	30	8	34	6	250	68	4
25	34	38	6	43	6	200	68	4
30	40	44	6	50	6	200	80	3
40	52	57	4	65	4	200	104	0
50	65	72	3	82	2	200	130	00
75	96	105	0	120	0	200	192	0,000
100	126	139	00	158	000	200	252	250,000
150	184	202	0,000	230	30,000	200	368	500,000
200	242	266	300,000	302	350,000	200	484	700,000

Use Column 4 for circuit from controller to motor for squirrel-cage and synchronous motor and for the entire circuit for wound-rotor motors.
Column 6 may be used for circuit ahead of controller for wound-rotor motors to permit larger line cutouts.
Use Column 9 for circuit ahead of controller for squirrel-cage and self-starting synchronous motors.
Use next larger wire size throughout for motors whose speed is below 600 r.p.m.

of starting equipment the Code permits that the switch or circuit breaker may be omitted if the motor controller, with its overload device, disconnects all lines.

It is the best and safest practice, however, always to install a switch or circuit breaker ahead of a controller or starting device, thereby providing a safe and ready means of isolating the starting device for adjustment and repairs. If a motor cutout is required and is not otherwise provided, this switch should be fused. If motor protection is otherwise provided (of a type disconnecting all lines), the switch should not be fused. If a motor cutout is not required, the use of fuses at this point is optional.

The Code requires that all continuous-rated motors above 2 hp. used for constant-load duty be provided with motor cutouts. A motor cutout may take the form of fuses disconnecting all lines, in which case the fuses may be as large as 125 per cent motor current rating or the nearest larger size thereto. The motor cutout may take the form of an instantaneous-trip circuit breaker or instant-trip overload relays in connection with contactors disconnecting all lines. In this event the highest permissible setting is 160 per cent of the motor current rating. If the motor cutout takes the form of a time-element circuit breaker or time-element overload relays and contactors, the highest permissible setting is 125 per cent of the motor current rating.

Thermal relays alone, acting in conjunction with line contactors, do not afford complete overload protection and cannot serve as motor cutouts. In case of a short circuit or a ground these relays do not function instantly, but permit sufficient time delay to lead to damage. Frequently the thermal relay itself is damaged if the circuit is not promptly cleared.

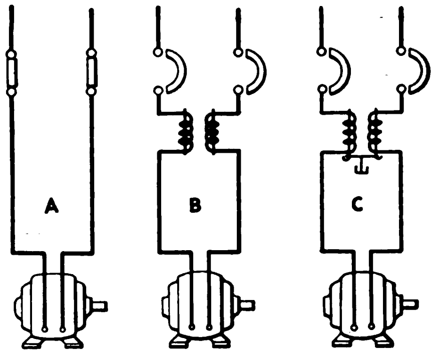


Fig. 1—This diagram shows the correct rating for fuses and setting of circuit breakers for the protection of 100-amp., continuous-rated motors.

The maximum rating of fuses in *A* is 125 amp. The circuits in *B* and *C* must carry 110 amp. continuously; therefore, the instantaneous circuit breaker in *B* must not be set over 160 amp., and the time-element circuit breaker in *C* not over 125 amp.

The Code does not require a motor cutout for motors having intermittent ratings or motors having peak load duty, for the reason that the line cutout is considered sufficient for the purpose. If the starters or controllers are grouped at a distribution point, however, feed lines and line cutouts are commonly omitted, in which case the motor cutouts are necessary.

It should be noted that with continuous-rated, constant-duty motors, a circuit of 110 per cent motor current rating is required between the motor and the motor cutout, yet it is permissible to fuse or set this cutout for 125 per cent of motor current rating. If a line cutout is used to protect the line between the motor cutouts and the mains this line must be protected on the basis of its rated current capacity. If this line represented 110 per cent motor rating, smaller fuses or a lower setting would be required for the line cutout than for the motor cutout, whereas the opposite condition is desirable. To avoid this situation, it is necessary to increase the size of the circuit between the mains and the motor cutout to permit the use of larger fuses or a higher setting. Thus, this circuit should be of at least 125 per cent of the rated motor current capacity.

The Code requirements both as to cable sizes and line and motor protection have been summarized and shown in abbreviated tabular form in Table I. Figs. 1, 2, 3 and 4 have been included in order to show typical examples of motor and circuit protection and wiring according to Code regulations.

Table VI—Cable Sizes for Three-Phase, 550-Volt Alternating-Current Motors

Horsepower	Full Load, Amp.	110 Per Cent of Full Load, Amp.	Cable Size	125 Per Cent of Full Load, Amp.	Cable Size	Starting Current: Per Cent Full Load, Current	Starting Current: Current, Amp.	Cable Size, Code Basis
1	1.5	1.7	14	1.9	14	250	3.7	14
3	3.9	4.3	14	4.9	14	250	9.8	14
5	6.3	6.9	14	7.9	14	250	15.8	12
7.5	8.8	9.7	14	11	14	250	22.0	10
10	12	13.2	14	15	14	250	30	8
15	17	18.7	12	21	10	250	43	6
20	22	24	10	27.5	8	250	55	5
25	27	30	8	34	8	250	68	4
30	32	35	8	40	6	250	80	3
40	42	46	6	53	5	200	84	2
50	52	57	4	65	4	200	104	0
75	77	85	2	96	1	200	154	000
100	100	110	0	125	0	200	200	0,000
150	147	162	000	184	0,000	200	294	350,000
200	193	212	0,000	242	250,000	200	386	500,000

Use column 4 for circuit from controller to motor for squirrel-cage and synchronous motor and for the entire circuit for wound-rotor motors.

Column 6 may be used for circuit ahead of controller for wound-rotor motors to permit larger line cutouts.

Use column 9 for circuit ahead of controller for squirrel-cage and self-starting synchronous motors.

Use next larger wire size throughout for motors whose speed is below 600 r.p.m.

Table VII—Recommended Practice for Motor Wiring

Type of Motor and Service	Cable Capacity in Per Cent of Rated Motor Current: Ahead of Controller	Cable Capacity in Per Cent of Rated Motor Current: From Controller to Motor
Direct-Current Motors:		
Shunt or compound-wound—constant load	125	110
Series or compound-wound—peak load	*	*
Alternating-Current Motors:		
Small single-phase types—constant load	125	110
Squirrel-Cage and Self-Starting Synchronous types, with Reduced Voltage Starting:		
0-30 amp. motor rating	250	110
Above 30 amp. rating	200	...
With full voltage starting	300	110
Wound-Rotor Induction Types:		
Constant load	125	110
Peak loads	*	*

* 110 to 250 per cent motor rating as shown in Table I.

All cable capacities refer to column *A*, Table II, if rubber-covered cable is used and to column *B*, if varnished cambric insulation is used.

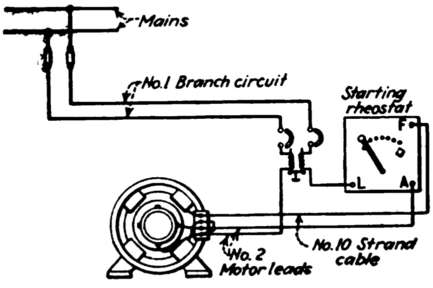


Fig. 2—Elementary layout showing the correct wiring (Code regulations) for a 20-hp., 230-volt, continuous-rated, 75.3-amp., d.c. shunt motor.

An 85-amp. capacity time-circuit breaker with a setting not to exceed 95 amp. is specified, with line cutouts fused for 100 amp.

In the above discussion, Code rulings and recommendations have been set forth. These represent a minimum standard of safe practice. They do not necessarily guarantee a satisfactory installation in all cases. Their complexity is inimical to their general and proper application. In an endeavor to combine both Code requirements and desirable practices in as simple a summary as possible, Table VII has been prepared by the writer, setting forth the minimum cable sizes recommended for motor installations. These sizes must be checked for voltage drop wherever runs of any length are involved.

The recommended practices for motor wiring as indicated in Table VII are based upon the thought that the branch cables ahead of controllers should be large enough to permit the cutout at the feed end of the branch circuit to be set at least as high as is permissible for the motor cutout. The writer considers that the proper place for motor protection is at the motor controller and not at some remote point, such as the source of the branch circuit feeding the controller. In fact, it is often desirable to eliminate, so far as possible, such branch circuits feeding individual motors, either by combining several motors on one branch circuit or by grouping the controllers at the distribution point and eliminating branch circuits altogether.

Although Table VII differentiates between the cable sizes ahead of the controller and between the controller and the motor, it is frequently more practicable to use the larger size of cable throughout. Likewise, it is hardly necessary for an industrial plant to stock and use every size of cable. Some sizes may well be omitted from the list, and the next larger size substituted. The saving in inventory and handling through standardization will offset the higher cost and some benefit will accrue through the occasional use of oversize cable.

A matter of considerable importance, however, is the location of conduits with respect to the equipment involved. They should never be run above or in close proximity to furnaces, flues, and hot pipes for the same reason that open wiring would be considered dangerous in a like installation. Conduits which are buried underground permit of little heat radiation; so when wiring is to pass through underground conduits wire sizes as well as conduit sizes should be liberal. Metal conduits carrying heavy currents, particularly when buried, should be somewhat isolated from each other, for if grouped together too closely hot spots may result, leading to rapid deterioration of the insulation and subsequent failure to the installation.

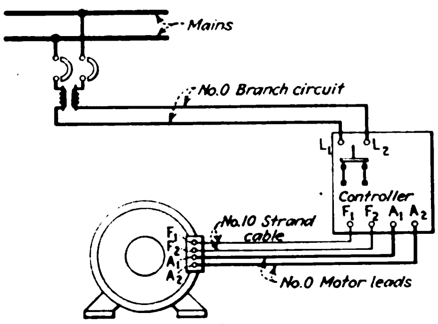


Fig. 3—Elementary layout showing the correct wiring (Code regulations) for a 20-hp., (120-min. rating) 230-volt, intermittent-rated, 75.3-amp., d.c. hoist motor.

No additional overload protection is required with the motor switch other than the 85-amp. capacity circuit breaker whose setting must not exceed 162 amp.

The sizes of conduits used naturally depend upon the cable to be contained. In wiring small d.c. motors, all wires may just as well be pulled in one conduit, but with larger d.c. motors it is advisable to run the shunt field leads in separate conduits because small cables are likely to be damaged when pulled in combination with large cables. Control pilot circuit wiring should not be mixed with motor wiring if this can be avoided. It is advisable to install very large cables in individual conduits, as conduit above 2 in. is difficult to work and a group of large cables may be hard to pull. Alternating-current leads must be so combined that all phases of one circuit are in one conduit. If this is not done currents may be induced in the conduit, causing it to heat. It should not be attempted to pull cable around more than four bends at the most in conduit of 2 in. or larger and this number is high if the runs are long or the cables heavy; where four bends are imperative a larger-sized conduit should be used.

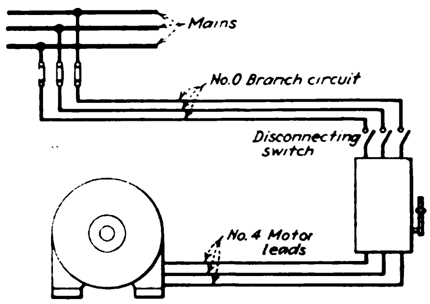


Fig. 4—This diagram shows the correct wiring (Code regulations) for a 40-hp., 440-volt, three-phase, 52-amp., continuous-rated, squirrel-cage induction motor with an auto starter.

The auto-starter overload trips are set at 63 amp. The line cutouts are fused for 200 amp.

Many motors are now provided with terminal fittings to which conduits may be directly attached; where the motor is mounted on a sliding base a short length of flexible conduit should be interposed. Open ends of conduits at motors in exposed locations should preferably terminate in

Table VIII—Conduit Sizes for Duplicate Cables 440-Volt Alternating-Current Motors

Size Cable B. & S. or AWG. Number of cables...	Size of Standard Conduit in Inches								
	1	2	3	4	5	6	7	8	9
14	½	½	¾	¾	1	1	1	1	1¼
12	½	¾	¾	¾	1	1	1¼	1¼	1¼
10	½	¾	1	1	1	1¼	1¼	1¼	1¼
8	½	1	1¼	1¼	1¼	1¼	1¼	1½	1½
6	½	1	1¼	1¼	1½	1½	1½	2	2
5	¾	1¼	1¼	1¼	1½	2	2	2	2½
4	¾	1½	1¼	1½	1½	2	2	2	2½
3	¾	1¼	1¼	1½	2	2	2	2½	2½
2	¾	1½	1½	2	2	2½	2½	2½	3
1	1	1½	2	2	2½	2½	3	3	3
0	1	2	2	2	2½	3	3	3	3½
000	1¼	2	2½	2½	3	3	3½	3½	3½
0,000	1¼	2	2½	3	3	3½	3½	3½	....
250,000	1¼	2½	2½	3	....	....	....	....	....
300,000	1½	2½	3	3	....	....	....	....	....
350,000	1½	3	3	3½	....	....	....	....	....
500,000	1½	3	3	3½	....	....	....	....	....

some form of fitting "looking down" so that dirt and moisture will not enter.

Sizes of conduits for various numbers of cables of one size are shown in Table VIII. These refer to ordinary cables for working pressures of 600 volts or less; however, for cables having extra insulation Fig. 5, based on the outside diameter of the cable, may be used.

Where a number of cables of different sizes are to be installed in one conduit Table IX may be used. This is based on the conduit area available as compared with that occupied by the cables. An example is given to show the application with R.C.D.B. 600-volt insulated wires.

Rubber-covered wire and cable are used in nearly all wiring for motor connections that are run in conduit. There are many grades of rubber insulation, but the new Code wire or cables are a minimum acceptable quality. The insulation on new Code wire and cable is made from rubber compounds with a minimum of fresh rubber. The fact that new Code wire and cable are passed by the National Board of Fire Underwriters does not signify that they are suitable for all uses. Where service conditions are at all severe or where reliability is of first importance it is recommended that wire and cable be specified to have not less than 30 per cent of Para rubber insulation, or that one of the higher-grade brands of rubber-covered wire or cable be used. The better quality material is somewhat more costly, but its use is fully warranted in many instances.

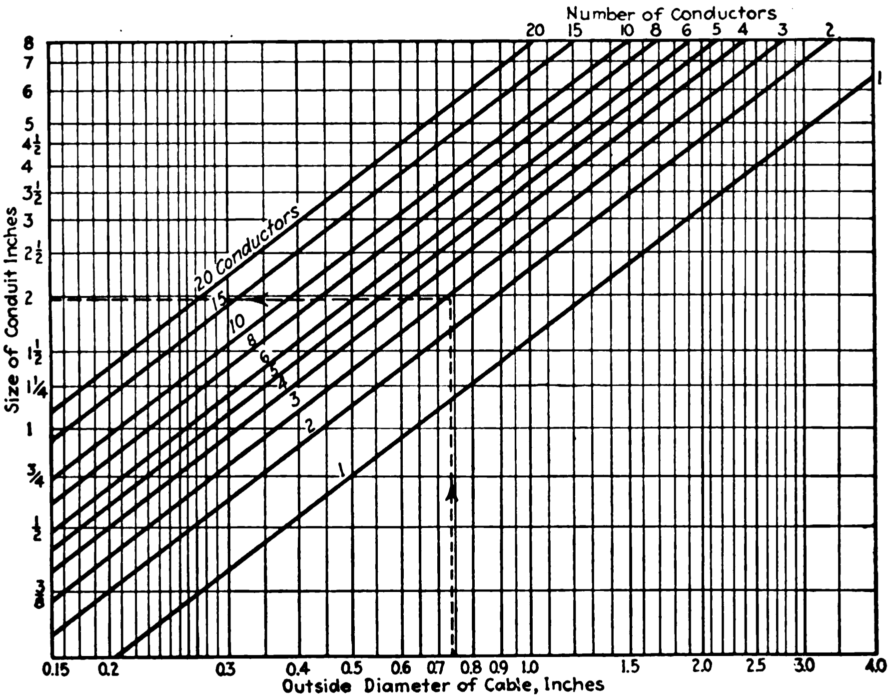


Fig. 5—Conduit sizes for high-voltage cables may be determined by means of this chart.

The conduit size is determined by tracing vertically from the line indicating the outside diameter of the cable in inches to the diagonal lines representing the number of conductors, and then horizontally to the conduit size on the left. An example is shown by the dotted line.

Table IX—Conduit Sizes for Different Sized Cables

SIZE OF CABLE B. & S. GAGE	CABLE SIZE, INCHES*	NO. OF CONDUCTORS FOR WIRE AREA 1	2	3	4	5	6	7	8	9	10	11	12	13	14
14	.250	.049	.098	.147	.196	.245	.294	.343	.392	.441	.490	.539	.588	.637	.686
12	.281	.062	.124	.186	.248	.350	.372	.434	.496	.558	.620	.682	.744	.816	.868
10	.312	.077	.154	.231	.308	.385	.462	.539	.616	.693	.770	.847	.924	1.001	1.078
8	.344	.093	.186	.279	.372	.465	.558	.651	.744	.837	.930	1.028	1.116	1.119	1.132
6	.437	.150	.300	.450	.600	.750	.900	1.050	1.200	1.350	1.500	1.650	1.800	1.950	2.100
5	.469	.173	.346	.519	.692	.865	1.038	1.211	1.384	1.557	1.730	1.903	2.076	2.249	2.422
4	.500	.196	.392	.588	.784	.980	1.056	1.372	1.568	1.764	1.960	2.156	2.352	2.548	2.744
3	.531	.222	.444	.666	.888	1.110	1.332	1.554	1.776	1.998	2.220	2.442	2.664	2.886	3.108
2	.594	.277	.554	.831	1.108	1.385	1.662	1.939	2.216	2.493	2.770	3.047	3.324	3.601	3.878
1	.656	.338	.676	1.014	1.352	1.690	2.028	2.366	2.704	3.042	3.380	3.718	4.056	4.394	4.732
0	.719	.406	.812	1.218	1.624	2.030	2.436	2.842	3.248	3.654	4.060	4.466	4.872	5.278	5.684
00	.750	.442	.884	1.326	1.768	2.210	2.652	3.094	3.436	3.978	4.420	4.862	5.304	5.746	6.188
000	.812	.518	1.036	1.554	2.072	2.590	3.108	3.626	4.144	4.662	5.180	5.698	6.216	6.734	7.252
0000	.875	.601	1.202	1.803	2.404	3.005	3.606	4.207	4.808	5.409	6.010	6.611	7.212	7.813	8.414
200,000	.906	.645	1.290	1.935	2.580	3.225	3.870	4.515	5.160	5.805	6.450	7.095	7.740	8.385	9.030
250,000	.937	.690	1.380	2.070	2.760	3.450	4.140	4.830	5.520	6.210	6.900	7.590	8.280	8.970	9.660
300,000	1.000	.785	1.570	2.355	3.140	3.925	4.710	5.495	6.280	7.065	7.850	8.635	9.420	10.20	10.99
350,000	1.062	.887	1.774	2.661	3.548	4.435	5.322	6.209	7.096	7.983	8.870	9.757	10.64	11.53	12.42
400,000	1.094	.950	1.900	2.850	3.800	4.750	5.400	6.650	7.600	8.550	9.500	10.45	11.40	12.35	13.30
450,000	1.156	1.049	2.098	3.147	4.196	5.240	6.414	7.343	8.392	9.441	10.49	11.54	12.59	13.64	14.69
500,000	1.187	1.107	2.214	3.321	4.428	5.535	6.642	7.749	8.856	9.963	11.07	12.18	13.28	14.39	15.50
750,000	1.375	1.485	2.970	4.455	5.940	7.425	8.910	10.39	11.85	13.36	14.85	16.33	17.87	19.30	20.79
1,000,000	1.531	1.770	3.540	5.310	7.080	8.870	10.62	12.39	14.16	15.93	17.70	19.47	21.24	23.01	24.78

*Outside diameter of R. C. D. B. 600-volt insulated cables.

Area of Conduit Sq.In.	Size of Conduit In.
.196	⅜
.307	½
.532	¾
.862	1
1.485	1¼
2.040	1½
3.341	2
4.784	2½
7.366	3
12.588	3½
16.209	4

EXAMPLE:

What size of conduit is required for 6 No. 8 and 6 No. 2 cables?
Area of 6 No. 8 = 0.558 sq.in.
Area of 6 No. 2 = 1.662 sq.in.
Total Area = 2.220 sq.in.
12 cables should give an area no greater than 37% of the area of the conduit.
Area of above 12 cables = 2.220 sq.in. which divided by 0.37 gives the area of conduit required.
$2.22 \div 0.37 = 6$ sq.in.
6 sq.in. = 3 in. standard conduit.

No. of Conduit	Per Cent of Inside Conduit Area
1	.56
2	.32
3	.42
4	.40
5 and over	.37

The Code requires multiple-conductor lead-sheathed cable in conduit for wiring of motors above 550 volts, except in power houses or substations.

Rubber insulation deteriorates, particularly at the higher temperatures. The maximum temperature allowable by the A.I.E.E. rating to avoid excessive depreciation is 50 deg. C., whereas varnished cambric insulation has the advantage in that it does not deteriorate so rapidly; consequently, a temperature of 75 deg. C. is permitted. Therefore, it is permissible to work this cable a little harder (voltage drop not considered) and it is better adapted for warm locations. Its use is not permitted for cables smaller than No. 6 B. & S. gage when subject to bending. "Slow-burning" insulation consisting of braids impregnated with flame-proof compound will sucessfully withstand still higher temperatures and is, therefore, given a higher current rating in the Code, but this insulation does not resist moisture successfully and is adapted for dry, hot locations only.

Protection of Cords for Portable Electric Tools

By FRANCIS A. WESTBROOK
Construction Engineer,
New Canaan, Conn.

USE of portable electric tools is increasing so rapidly and is becoming so important a factor in many industrial operations that anything which tends to influence their efficiency in one way or another is of great importance. Probably no one factor has so great a bearing on this question as the flexible electrical conductors, or "cords," which supply these tools with power. Not only is the actual make-up or construction of the cord of importance, but other details such as the manner in which the conductors are terminated at the tool, how they are supported to keep them out of the way of the operator, and so on, may determine the usefulness of the tool.

For instance, if the cord of an electric industrial iron is continually burning off where it is attached to the iron, or if it is always in the wrong place, so that it impedes the operator and lessens his production, it may be more economical to forego the obvious advantages of electric heating and go back to the old-fashioned, gas-heated irons. In other words, the cord used on a portable electric tool is absolutely essential, but if it is not of the proper kind and properly installed, it may seriously lessen the value of a useful tool.

Before going further into the subject, it may be well to say that there are now two general classes of cords on the market: those with an outside covering consisting of a braid, and those having a bare rubber jacket. The former are, as a general rule, cheaper in first cost than the latter, but it should be clearly borne in mind that savings in first cost are no more a guide as to what will prove to be the most economical in the long run in this connection than in any other engineering relationship. Obviously, it is poor economy to permit interruptions in the service of portable machines, involving also the cost of patching or changing cheap cords, when an expenditure of a few cents more per foot would very greatly reduce such losses.

Braided cords that are not capable of withstanding as much mechanical wear and tear as rubber-sheathed cords should, therefore, be used only where the service conditions are not severe.

In order to find out how different industrial users of portable tools have overcome troubles with their cords, an investigation was made in a considerable number of plants, covering a variety of conditions where such tools are being successfully used.

The hat factory of Crofut & Knapp at South Norwalk, Conn., uses about 500 electric irons. The majority are of a very heavy and rugged type with the cord permanently attached to mica-insulated terminals protected by a movable cap. In addition, some irons of the domestic type are used, which furnish a very interesting basis of comparison. Most of the trouble experienced is due to the conductors breaking at the terminals.

The type of cord used for this service has two No. 18 A.W.G. stranded conductors covered with a cotton wrapping, rubber insulation and asbestos braid, with an outer covering of cotton braid over both conductors. The conductors are skinned and rewrapped with asbestos cord up to the point where they are attached to the terminals on the iron. Tape is not used at all. It has been found that the asbestos cord, being stiff, easy to apply and fireproof, is more satisfactory than the tape that was formerly employed. Its use has reduced failures to a marked extent. There is no other protection or mechanical strengthening at the iron, except that the cord passes through a spiral spring about 5 in. long, as shown in Fig. 1.

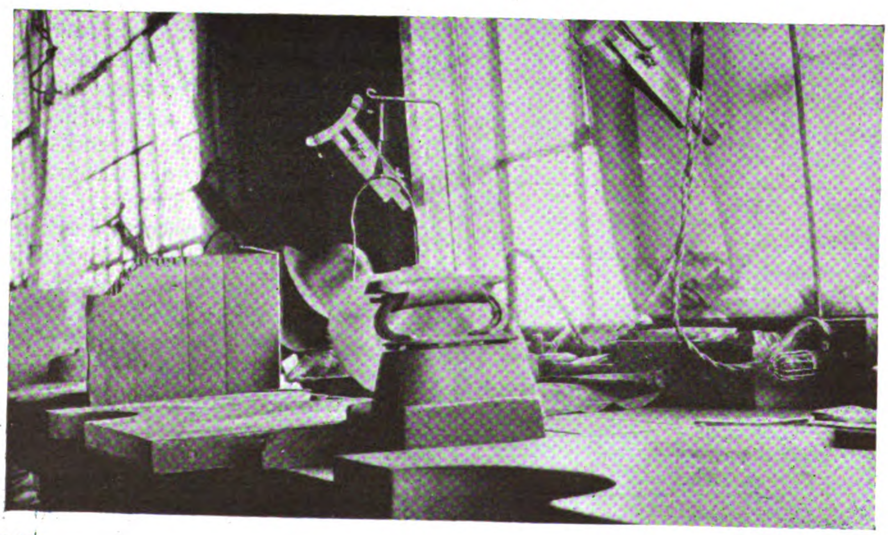


Fig. 1—Cords for heavy irons are supported by a spiral spring to keep them out of the way.

The cord is suspended from the spring by a loop of soft leather, and is protected against sharp bends at the iron by a stiff spiral spring about 5 in. long that encircles the cord. A pilot light on the outlet box at the extreme right tells the operator whether the current is on or off.

Fig. 2—The cord through which power is supplied to this "vibrator" is subjected to unusually hard service.

This device is used in the straining process during the manufacture of paint. In addition to the wear and tear incidental to being moved from place to place, the cord is frequently splashed with paint, oils and other liquids.

Two other means of protecting the cord are employed. One is a soft leather loop attached to a rather long but very resilient spring that can be drawn out to several times its original length by slight tension. The cord passes through this leather loop and as the operator works his iron back and forth this spring keeps the cord out of the way of his work. This arrangement, shown in Fig. 1, has greatly reduced burns, tending to shorten the life of the cords.

The other means of prolonging the life of cords is to clamp them at the outlet boxes close to the plug. These plugs also have red pilot lights to inform the operator when the heat is on. Switches are provided at the outlet boxes for turning the current on and off.

When new, the cords are 6 ft. long, and when they have been repaired so often that their length has been reduced to about 4½ ft., they are replaced, as by that time there are usually so many burns and the braid has become so much frayed that it is not worth repairing or saving for other purposes. The practice of splicing short lengths together and repairing a break near the middle has been given up, as it has been found that splices are certain to be weak spots that cannot last long, at best. With the present method, a cord needs attention about once a month, which does not seem excessive when it is considered that they are in constant use all day.

As mentioned before, a good many domestic irons are in use. The cord is attached to the plug for the outlet by making a half turn around the terminal. This provides adequate mechanical strength and seems to be preferable to making a knot in the cord, which strains the insulation and is likely to cause cracking and ultimate failure.

Likewise, in the manufacture of paints, a portable tool known as a "vibrator," shown in Fig. 2, is used in the straining process. This tool is moved about from place to place, and as the motor is small, the power is obtained by plugging into any convenient lighting outlet. The cord is not subjected to any severe mechanical abuse, because it practically never rests on the floor. It is, however, subjected to other seriously deteriorating influences. In the first place, the cord is continually splashed with paint, oil and volatile driers. Although this might be expected to have a deleterious effect on the rubber insulation, it has been found that a

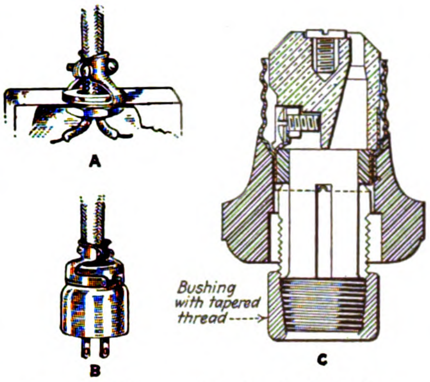


Fig. 3—The cord is firmly held by a clamping device as it enters these fixtures.

A shows an outlet box attachment manufactured by the Arrow Electric Co. The cap with a cord clamp shown in *B* is made by the Bryant Electric Co. *C* shows the details of a heavy-duty plug made by the Benjamin Electric Co. As will be seen, the bushing has a sharply tapered thread and screws over a fiber sleeve. When the bushing is tightened the fiber sleeve contracts and grips the cord.

cord with a heavy outside rubber jacket and no braid gives no trouble. Nor is there any trouble worth mentioning at the plug end of the cord; but a great deal of trouble was formerly experienced at the motor end. This was because the wires had to be brought into the motor terminals through a bearing stud on the motor. The stud was formerly prevented from turning by setscrews, which frequently sheared off, thus permitting the stud to turn and cut off the wires. This happened so often that an ingenious machinist, employed in one large paint factory, made a new stud with square corners and projecting lugs, so that it could not turn, and the trouble from cut wires disappeared. A serving of several thicknesses of ordinary rubber-filled tape is applied to the outside of the cord where it passes into the opening of the machine to prevent wear.

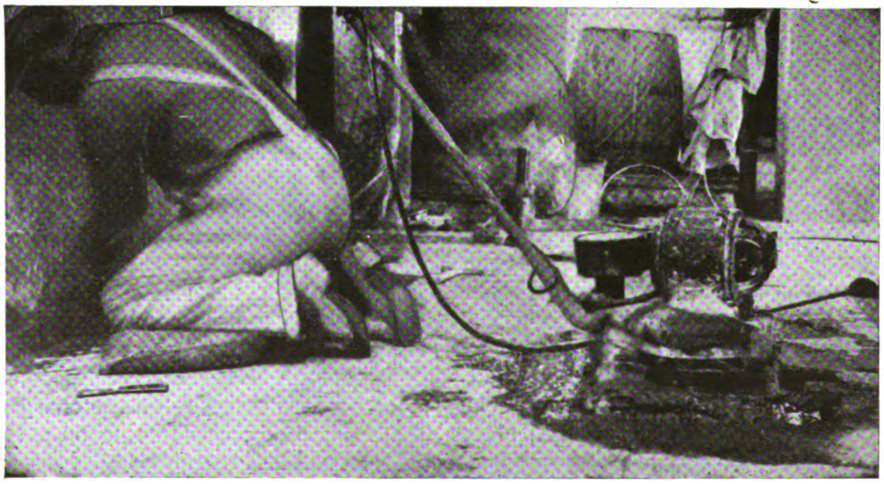
A good many portable electrical tools are also used at the works of the Terry Steam Turbine Co., Hartford, Conn. These consist mainly of drills and grinders, and the cords are subjected to very hard usage. Heavy castings are dropped on them; they come in contact with hot steam pipes; and they lie around in the dirt and oil which accumulate on the floor. Various schemes have been tried out in this plant to reduce cord failures to a minimum, but it has been found next to impossible to make a workman give the cords any special consideration. It is also impossible, under the conditions, to take any measures to keep the cords off the floor.

Adoption of a rubber sheathed cord in place of the reinforced braided cord, formerly used, resulted in a marked improvement.

In the building trades, where many portable tools are used by electricians and others, much the same service conditions obtain as in the industrial plants just described. Here, also, the same remedies for cord troubles are applied. Cords with rubber sheathing are widely used and various devices employed to relieve strain and sharpness of bending have done much to reduce the frequency of failures.

Even in ordinary building maintenance, the problem of the best type of cord to use, and how to protect it, cannot be ignored. One example of severe service is found in the case of a stone or composition floor polishing machine, such as shown in Fig. 4. The service end of the cord is usually plugged into a baseboard outlet and lies around in the mud and moisture where the polishing is under way. It is also likely to be walked on and otherwise abused. Plainly, trouble from failures can be reduced only by

Fig. 4—The cord on this floor polishing machine is subjected to severe mechanical abuse, as well as exposure to dirt and moisture.



the use of a strong, rugged cord that is adapted to the conditions under which it is used.

A good many different makes of portable electric tools are, of course, in use and some of them are now being provided with more or less suitable means for attaching the cords. In some instances there are plug attachments on the tool, and in others the flexible cord is permanently attached to the tool and is removable only at the service outlet. The latter arrangement has the disadvantage that when the cord fails, the whole tool is out of commission. On the other hand, if there is a plug attachment at the tool it is a simple matter to have a few spare cords on hand, fitted with plugs, and to substitute a new cord when the one in use gives out.

It is interesting to note that the manufacturers of wiring devices, as well as users, have tried to eliminate some of the abuses of flexible cords. There are now various devices on the market for taking up the mechanical strain. For instance, everyone is familiar with the small fiber cleats used for the cords on telephone instruments and which, in fact, are used at times for cords such as those we are considering. Furthermore, various manufacturers make plugs and sockets with devices for securely gripping the cords as they enter. Three typical devices are shown in Fig. 3.

Contributing Causes Of Industrial Accidents

By G. E. KIMBALL
Electrical Engineer,
Industrial Accident Commission of California,
San Francisco, Calif.

EXPERIENCE obtained in nearly ten years of electrical inspection work with the California Electrical Safety Orders, which require safe electrical installations in places of employment, has very clearly brought out the fact that electrical installations must be made as nearly foolproof as possible. If electrical equipment is installed in a manner that will permit of its safe use by persons who are too busy with their work to give thought to the possibility of injury, the equipment will have been made reasonably safe for those who are ignorant of its dangers.

The old saying that it is a hard task to educate the public is fully corroborated by the long lists of automobile accidents that are published in our daily papers, despite the vigorous educational campaigns which are being carried on by hundreds of agencies. Innumerable ordinances have unquestionably helped thinking people, but one moment of thoughtlessness may offset years of careful conduct.

Educating workmen along the lines of accident prevention in shops, mills and factories is no less difficult. Electrical installations in such places cause but few accidents as compared with those caused by automobiles, yet they may be considered in much the same way. Thoughtlessness, carelessness and ignorance are the chief contributing causes of accident and these may not always be charged against the injured person.

The first of several electrical accidents that have come to the attention of the Commission will be outlined and the reader will be allowed to judge whether the victim was responsible.

A workman, employed as a machine hand in a large shop, was standing on a steel plate that covered a floor opening between two machines. The plate was in contact with the frame of one of the machines, and this machine was accidentally charged with 440 volts. A metal hood had been provided to cover the motor, with a slot cut in the hood through which the wires were run between the terminals of the motor and a conduit fitting. The conduit had been terminated within a few inches of the frame of the motor, but was not metallically connected with or bonded to the motor. Vibration of the hood had chafed the insulation away from one of the conductors entering the motor and the hood was in metallic contact with this wire at the time of the accident.

When it occurred, the machine operator was standing on the charged metal plate and was pulling on a set of chain blocks supported from a bracket on the frame of an adjacent machine. This other machine was grounded and the operator was in good contact with this ground through the chain. Consequently, while he was standing on the charged steel plate, the circuit was completed through his hands and feet from one machine to the other.

The bank of 440-volt, three-phase transformers supplying the shop was not normally grounded. However, an accidental ground was placed on the system each time the motor starting switch for a small suspended grinder was operated. Within the conduit terminal fitting on the frame of this small motor, one of the wires or terminals was in contact with the grounded frame of the motor, so that each time the starting switch was closed it grounded the entire 440-volt system.

While the operator was pulling on the grounded chain and standing on the charged plate, another employee closed the starting switch for the grinder and a circuit was completed through the body of the operator, between the two machines, nearly a hundred feet away. Artificial respiration was tried, but he had been instantly killed.

The California Electrical Safety Orders require non-current-carrying metal parts of electrical equipment to be effectively grounded. Conduit terminal fittings must be provided at the frames of all motors and the wiring completely inclosed. Had such a fitting been provided at the frame of the motor where the insulation was worn off the wire, the accident could not have occurred. On the other hand, the fitting that was provided on the frame of the grounded motor operating the grinder did not give sufficient room within the casting to insulate properly and inclose the bolted connections when the cover was in place. When an order or rule is issued as a safety measure one can almost be certain that it was prompted only by past experience with the particular hazard.

Caution should not be confined alone to the operation of electrical equipment, but should be exercised in the design and manufacture of all materials and equipment that may be used in an electrical installation in use in an industrial plant.

In particular, care should be taken to see that electrical equipment and material are not installed in places or applied in types of service for which they are not intended by the manufacturer.

Construction details of

Short-Type Coils and Winding Molds

By A. C. ROE
and
D. H. BRAYMER,
Consulting Editor, Industrial Engineer

THE SHORT-TYPE COIL derives its name from the fact that by its use, the over-all length of the armature is greatly reduced. This is accomplished by arranging the coil ends so that there is minimum projection beyond the core. This coil construction is a combination of the diamond and involute coils. Little information has heretofore been published on the construction and use of this type of coil. This article will, therefore, be of interest to repair shops and industrial plant men who have to rewind machines in which this type of coil is used.

THE short-type coil described in this article is a combination of a diamond and an involute type of coil-winding arrangement. A plan view, Fig. 1, of a short-type coil construction shows how the ends start away from the slot sections in a manner similar to the diamond coil and at a short distance are then squared off. The plane of the coil ends rolls 90 deg. at the change from diamond to involute. It is the squaring off of the diamond ends that gives the coil the name "short type."

The rear and front ends of a short-type coil are shown in Fig. 2. The center part that is shown three wires deep is the involute section of the end winding. The part to the right that is shown four wires deep is the top half, diamond-end part of the coil. This view also shows the roll or change in the plane of the diamond and involute sections. Fig. 2 also shows another characteristic of the short-type coil end—namely, in the change from the top half to the bottom half the wires roll over 180 deg. For example, consider the top wires of the bottom half of the coil, to the left in Fig. 2, which are the lead wires. Then follow these wires across the involute and note that they are now on the inside. On the right these wires are shown on the bottom of the diamond end and in the same position in the top side of the coil as it lies in the slot.

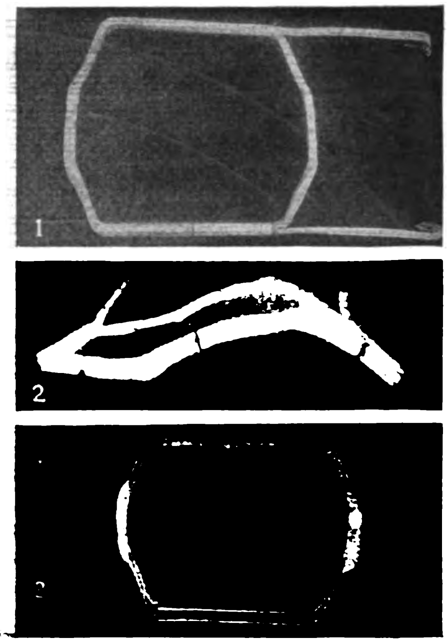
This practice brings out two rules that hold for all short-type coils: (1) With leads brought out on top of a coil as in Figs. 1 and 2, the starting lead in winding the coil is on the section of the coil that is to be in the bottom of the slot. (2) With leads brought out on the bottom of the coil, the winding of the coil must be started on the section that is to be in the top of the slot.

There are four distinct methods of winding short-type coils, and as each method calls for a change in the layout, an explanation of each method will be given.

Method No. 1—The coils are wound single as in Fig. 3—that is, the total number of single coils used in any given armature must be wound and then 1, 2, 3, 4, 5, etc., single coils assembled after winding, in order to make a complete winding unit. For example, assume an armature having 49 slots and 97 bars, for which we would have to wind 98 single coils and assemble two single coils after being wound to make 49 winding units. The terms "two-coil tie," "three-coil tie," etc., indicate the number of coils to be assembled in order to make a complete winding unit. Fig. 3 shows a short-type, single coil with two coils assembled so as to make one unit or a two-coil tie. Such a coil is said to be "wound single."

Figs. 1, 2, and 3—Short-type coils wound in one operation.

The ends of the coil in Fig. 1 look like a diamond coil squared off. The end of the short-type coil in Fig. 2 shows the roll or twist of the diamond and involute sections. A short-type single coil is shown in Fig. 3 with two coils assembled to make one unit or two-coil tie.



Method No. 2—All single coils are wound on the mold together or a complete winding unit is wound at one operation. Figs. 1 and 2 show a one-operation coil, hence the term short-type (combination) or one-operation coil.

Method No. 3—In this method the location of the slot sections are one above, and one below, the throw line. Either the single or combination coil can be wound in this manner. The meaning of "above" and "below" the throw line is explained as follows: When making molds for the short-type coil, two sections of hard wood are used, but the two parts are not fastened together. One part is fastened to the winding machine, whereas the other part must be removable in order to permit the coil to be removed after it is wound. It is standard practice to lay the mold out with the throw line as the line of separation. The term throw line will be explained later.

In Fig. 4 the end view of a short-type coil mold is shown. The shaded section of the sketch represents one section of the mold and the light part the other section. The line *XY* is the throw line which separates the slot sections of the coil. The bottom slot section of the coil is shown below the throw line and the top half above the throw line.

Method No. 4—In this method both slot sections of the coil are above the throw line, as shown in Fig. 5. The short-type coil does not need a coil support. The involute section of the coil ends makes the construction rigid and when banded it is as good mechanically as any diamond coil with coil supports. The involute part of the coil also keeps the top and bottom

layers of the diamond parts of the coil end further apart, so that insulation between the coil ends while winding the armature is unnecessary with short-type coils.

When laying out a short-type coil for a given armature the following information must be known: The diameter and number of slots in the armature; the size of wire, turns per coil, and the arrangement of the wires in the coil (that is, the number of wires deep and wide); insulation on coil ends and in the slot section; the distance the coil can extend out from the core on both ends; and how much the winding can drop below the outside diameter and still clear oil throwers, thrust rings, etc.

There are certain basic dimensions used in laying out a short-type coil, and these may be obtained mathematically or by direct measurement from the armature. The coil can then be laid out on a paper to full scale or half size.

The first step is to draw a line representing the outside diameter of the armature, as an arc or line *A* in Fig. 6. Next draw in the lines *2* and *3*, to represent the center lines of the slots in which the coil lines are drawn. Angle *O* equals $(360 \div N) \times$ coil throw or pitch in slots, where *N* equals the total number of slots. The chord of the angle *O* on the outside diameter *A* in Fig. 6 equals the diameter of the armature times the sin $O \div 2$.

A practical method of locating the lines *2* and *3* in Fig. 6 is to plug two slots (the coil pitch part) with wood blocks cut off flush with the top of the armature but projecting beyond the end of the core. Then with a pair of dividers lay off the distance between the center lines. Transfer this dimension to the drawing and draw in the lines *2* and *3*. Next, mark off the bottom of the slots on these two center lines and from line *A* in Fig. 6 lay off on the center lines a distance equal to the thickness of wedge used. Midway between these two points draw the line *B*. This line represents the line on which the bottom of the top half of the coil and the top of the bottom half of the coil lie when leaving the slots.

Next, the line *TL*, or throw line, is drawn from the points on the center lines of the slots where the line *B* crosses them. Thus, in this case the throw line is the distance between the center line of the bottom of the top half of the coil and the center line of the top of the bottom half of the coil, as points *a* and *b* in Fig. 6.

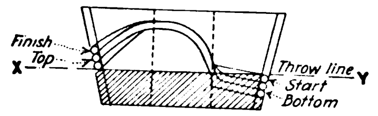


FIG. 4

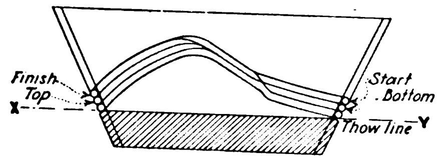


FIG. 5

Figs. 4 and 5—End views of mold for winding short-type coils.

Fig. 4 shows the top side of the coil above the throw line and the bottom side of the coil below this line. In Fig. 5 both top and bottom sides of the coil are above the throw line.

The coil sections shown in Fig. 6 need not be drawn in, but they are shown in this case only to help in the understanding of the various lines and their relations.

The distance *d* from line *3* to line *5* is the thickness of one insulated wire or single coil. The angle *M* is the distance between the center lines of the adjacent slots and equals $360 \div N$. The chord *C* equals the diameter of the armature times sin $M \div 2$. This also can be measured directly on the armature with the dividers. The depth of the insulated wires in the slot is indicated by *WS*, as the wire space in Fig. 6.

We are now ready to lay out the end winding, which is done in the same manner as for a diamond-shaped coil, and is illustrated in Fig. 7. First draw the line *XY*, which represents the end of the armature core iron, and then the line *CD*, which represents the distance the bottom cell projects beyond the iron. Next draw in the line *AB*, which is the distance the top cell extends beyond the core. The distance *F* is the difference between the top and bottom cell extensions.

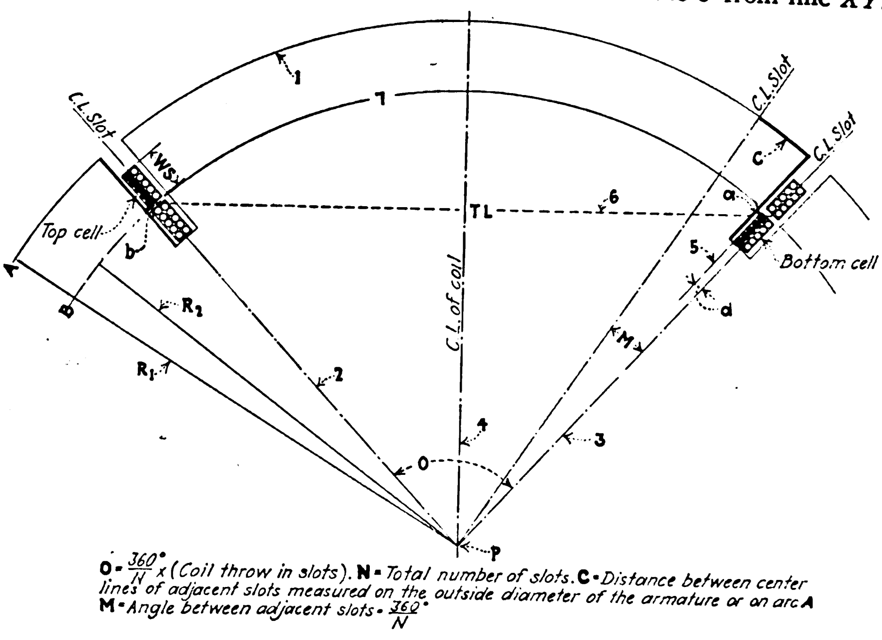
Next, the distance *P* is determined, and it is found to be equal to $R_2 \times 6.2832 \times T \div N$, where *T* equals the pitch of the coil expressed in slots. That is, for a coil pitch of 1 and 1*P*, *T* equals 5. R_2 is taken from Fig. 6.

With *P* known, lay off lines *4* and *5* as shown in Fig. 7. Then find the distance *S* equal to *T*, which is also the developed distance between the center lines of slots on the line *B* of Fig. 6.

Next, find the insulated thickness of the coil at *L* as in Fig. 7A, plus any air space required between the ends, and with *L* as a radius describe arcs *9* and *10* in Fig. 7. From point *A*, Fig. 7, draw a line that just touches or is tangent to the small arc *9*. This is line *AE* in Fig. 7, and from the point *D* draw the line *DE* also tangent to arc *10*. This line may meet line *6* at the point *E*, or below it. The point *E* in Fig. 7 indicates the position of the center line of the pin for a diamond coil.

The next step is to find the distance *EX* (Fig. 7A), which represents the extension of the center line of the involute *JK* beyond the core or line *XY*. This can be determined from the amount of end room available, but in locating the line *JK* allowance must be made for the distance (*WS* plus the insulation)$\div 2$, which is one-half the wire space plus the insulation used on the coil ends. That is, the total coil extension is $EX + (WS + \text{the insulation}) \div 2$. Measure this distance on line *6* from line *XY*.

Fig. 6—This diagram shows how to lay out a short-type coil from the measurements taken from an armature.



$O = \frac{360°}{N} \times$ (Coil throw in slots). N = Total number of slots. C = Distance between center lines of adjacent slots measured on the outside diameter of the armature or on arc A. M = Angle between adjacent slots $= \frac{360°}{N}$

and draw line JK until it meets lines AE and DE. Then from points J and K drop the perpendicular lines *14* and *15* and divide the distance P into three parts as H, M, and N.

The distance M in Fig. *7* is the length of the involute and it is seldom found to be greater than 40 per cent of the distance P, but, in general, the longer the line JK or distance M, the deeper the end winding will be and the shorter the distance EX (Fig. *7A*). Thus the two limits are coil extension and depth.

In Fig. 8, diagrams A, B, and C show the various steps in building up the layout of Fig. *7*. We can obtain from Fig. *7* a tentative location of the involute to use in Fig. 9 in order to finish the layout. Space off the distance in Fig. *7* between the center lines of the slots. We find, then, that point K falls on the center line of slot *5* and that point J is approximately 1/8 in. to the left of the center line of slot *9*.

Fig. 9 is the same as Fig. 6 except that the arc *3* has a radius equal to R_3, or the diameter of the smallest circle that the bottom of the involute can ride on. Thus, R_3 is the maximum depth of the winding. Points on the outside radius A have been laid off equal to the distance between the center lines of slots *1* to *13*. In Fig. 9 from points on arc A drop lines KK_1 and JJ_1, locating the distances N, M, and H on the correct throw line, TL. Next, draw the arc or line *4*, which is equal to R_2 plus the wire space. This line represents the top of the coil.

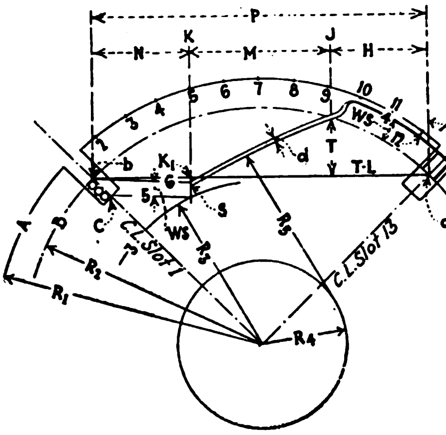


FIG. 9

From point C, which is the bottom of the coil at the center line of slot *1*, draw a straight line to the point on arc *3* where line KK_1 meets it, and from point B draw a line, *6*, parallel to and a distance WS above line *5* until it meets line KK_1. Call this point S. Point S falls below the throw line, for the case under consideration, but it can be above or below it. This point S is one of the most important factors of a short-type coil, as it affects the winding of the coil and also the winding of the armature. The farther point S falls below the throw line the harder it will be to wind the coils, as the wires will fall down on the bevel with the first turn on the throw line, as shown by the small circles in slot *1*. This first turn must be held up so that the second and succeeding turns can be wound.

Figs. 7, 7A, and 8—The shape of the ends of the coil is determined as shown in these diagrams.

The steps in the construction are shown in Figs. 7A and 8. Numbers *1* to *15* indicate the order in which the dimensions are used.

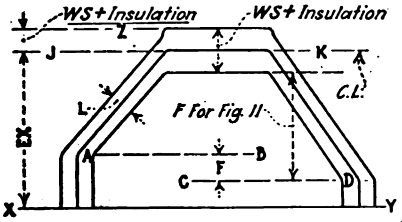


FIG. 7A

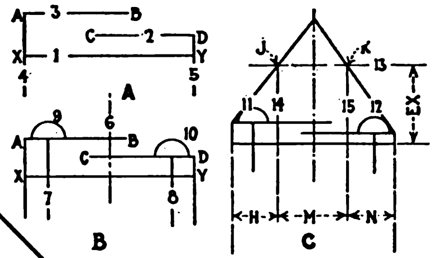
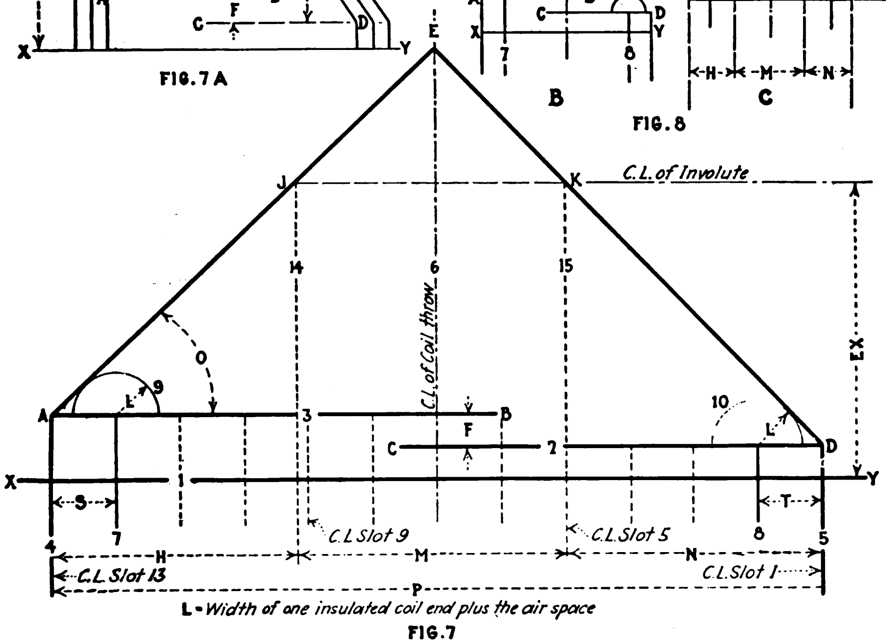


FIG. 8



L = Width of one insulated coil end plus the air space

FIG. 7

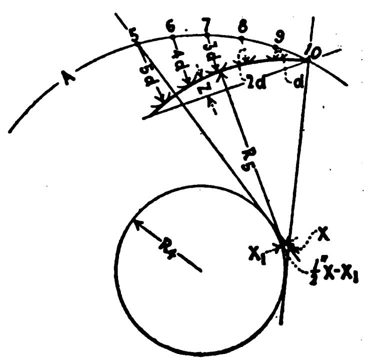


FIG. 10

Figs. 9 and 10—These diagrams show how the involute section of the coil end is constructed.

The diagram in Fig. 9 is the same as that in Fig. 6. The diagram in Fig. 10 supplements that in Fig. 9 and shows how the angle of the involute is determined so that the short-type coil will wind properly.

On the other hand, if point S is brought up above the throw line, it means that the involute is flattened out, distance N is increased and M decreased. If this is done, there will be trouble in winding the armature, as the winder will have to beat coil point S down to prevent the top section of the coil projecting above the line A, the outside diameter of the armature. But the angle O and line EX in Fig. *7* limit the amount that point S can be varied, so that the only other thing to do is to ease up on the bevel used on the mold for the bottom slot section, or reduce the pitch of the coil by one slot.

It is plain, therefore, that care must be exercised in selecting point S. In order to reduce the distance K_1S (Fig. 9), the length of N must be increased, which in turn means that the line EX must be lengthened or the coil extension increased. If point S is satisfactory, then the distance T can be measured directly from the layout.

The next step is to check the angle of the involute section to determine whether the coils will wind without building up. This can be done in the layout, Fig. 9, but to make the method clear a separate sketch will be used.

In Fig. 10 line A is the same as in Fig. 9. Then on this line, starting at

any position, lay off six points as *5, 6, 7, 8, 9,* and *10,* representing the center lines of slots. From point *9,* Fig. 10, describe the small arc as shown, the radius of this arc being equal to D of Fig. 9, which is the insulated thickness of the complete coil at the involute section. This dimension D also includes any air space wanted. Then from point *8* describe the next small arc with a radius of $2D$, and from each of the other points describe small arcs with a radius as indicated in Fig. 10, which is equal to the number of coil ends that must pass the point in question.

The next step is to find a radius $R5$ that will touch all small arcs. One method is to draw the small circle with a radius $R4$ (Figs. 9 and 10), which radius is equal to $(N \times L) \div 6.3$. Then from points *5* and *10* in Fig. 10 draw two lines as shown tangent to the $R4$ circle. Midway between the point x, where these two lines cross, and the circumference of the $R4$ circle will be found the center point of a radius, $R5$, that will touch all the small d arcs.

It will be noticed that the slots *5, 6, 7, 8, 9,* and *10* used in Fig. 10 were taken from Fig. 9 to be the points that fall on line KJ. When the distance Z (Fig. 10) does not exceed ¼ in., or ⅜ in. for light coils, the involute part may be made a straight line. This line is drawn from point S (Fig. 9) to the point on the line JJ_1 T inches above the throw line.

The next step is to record the dimensions found by means of the coil layout in a form that can be kept and used in the construction of winding molds. The form shown in Fig. 11 can be used for all short-type coils wound single or in one operation and with cells, one above and one below the throw line.

The bevels Q and S are obtained from Fig. 9 by erecting a perpendicular line from points a and b and measuring from the throw line to the point on this line where the center line of the slot is 1 in. from the line. This is shown in Fig. 9 at the center line of slot *13.* The letters in the sketch (Fig. 11) show the location of each corresponding letter as found in the layouts and insures a standard method of recording dimensions. After the terms *leads on, start on,* and *wound,* two classifications are given. The one not used is to be crossed out. The remaining terms give full data for making future coils. The addition and filling out of the terms, *wound single,* or *one operation,* is important, for the dimensions B, H and N must be changed to suit the type of coil.

In Fig. 9 the throw line is shown as being the distance between the center line of the bottom of the top half of the coil and the center line of the top of the bottom half of the coil; this is the standard designation for the B dimensions. But this is not always correct, for in coils wound single and consisting of more than one single coil per winding unit the discrepancy is greater the larger the size of wire and the number of single coils used.

Figs. 12, 13, 14, and 15 show the effect of making the B dimensions on the mold less than the throw line. In Fig. 12 a single coil is shown, with the throw line to the center of the coil. Then as the coil is actually wound on, the line AC, which is $d \div 2$ less than the throw line dimension (where d is the insulated diameter of the wire used), it follows that the finished coil is $d \div 2$ wider than the layout dimensions. This extra coil width depends on the size of the wire, and in cases where the slot is deep, it will facilitate pulling the top half of the coil over the tooth and into the slot.

Two single coils are shown in Fig. 13. The center line of the slots falls between the two single coils. The black circles indicate the one single coil that would be wound on the mold, and as the bottom side would be wound on the line AC, it is evident that if the B dimension is the same as the throw line, the coil will be wider than the layout coil by an amount equal to d.

Fig. 14 shows a three-single coil, which falls into the same class as those in Fig. 12.

A four-single coil, shown in Fig. 15, is the same as those in Fig. 13. This leads up to the rule that for a unit having an odd or even number of single coils, the B check will be d greater than the layout throw line.

Fig. 11—Data form for recording the information from coil layouts for the construction of winding molds.

Mold Data for Short Type Armature Coil

________ Hp. ________ Volts ________ RPM. ________ Poles

Type ________

Diam. of Arm ________ Length of Coil ________ No. of Slots ________

Coils per Slot ________ Turns per Coil ________ Size of Wire ________

Coil Pitch ________ Wire Space ________

A ________ K ________

B ________ R_2 ________

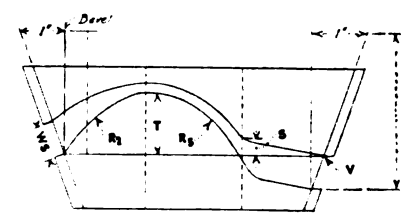
H ________ T ________

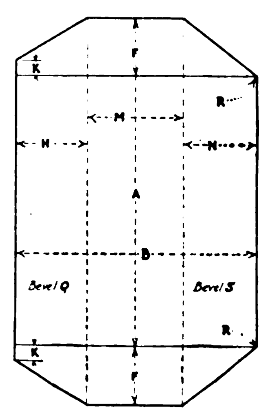
M ________ S ________

N ________ R_5 ________

F ________ Bevel Q 1 in. x ________

R ________ Bevel S 1 in. x ________





Leads On Bottom / Top

Start On Bottom / Top

Wound Single / One Operation

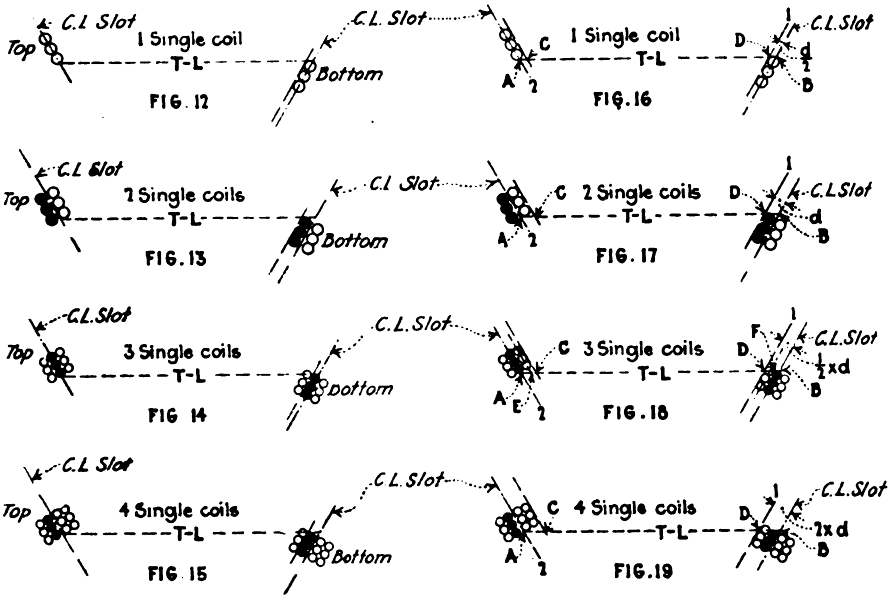
Winding Mold No. ________

These rules apply only to coils wound single. It also means that with large wire, and for close design, the variations as outlined must be taken into consideration. In most cases, however, the B dimension on the mold sketch can be made equal to the throw line as found in Fig. 9.

In Fig. 11, the distance K is the amount the top cell projects beyond the bottom cell on one end and in most cases is ¼ in., but for coils wound with wire of large size, as No. 8 and above, it may be as much as ⅜ in. The distance A equals the length of the armature core plus any coil extension. The amount the bottom coil extends past the core should not be less than ¼ in. for voltages up to 600 and should be ½ in. when end room permits. While ¼ in. to ¾ in. is the range, it can vary depending upon the end room and size of wire. A heavy coil will require more slot extension than a light coil, which is due to the fact that the bevels of short-type coils are seldom correct and placing the top half of the coil in the slots tends to twist the bottom section. Also, the longer cell extensions allow more spring to the coil in pulling it over and into the top slot.

The dimension R is the radius used on the mold at the ends of the slot sections, and varies from 1/16 in. to ¼ in., the 1/16-in. value being used for wire up to No. 15, and ⅛ in. for No. 14, and the larger sizes. The radius R used decreases the total length of the straight part and with any given set of values for Fig. 11 the total length of the slot sections depends on

Figs. 12 to 19—These diagrams show the effect of making the B dimension of the winding mold equal to, less, or greater than the throw line.



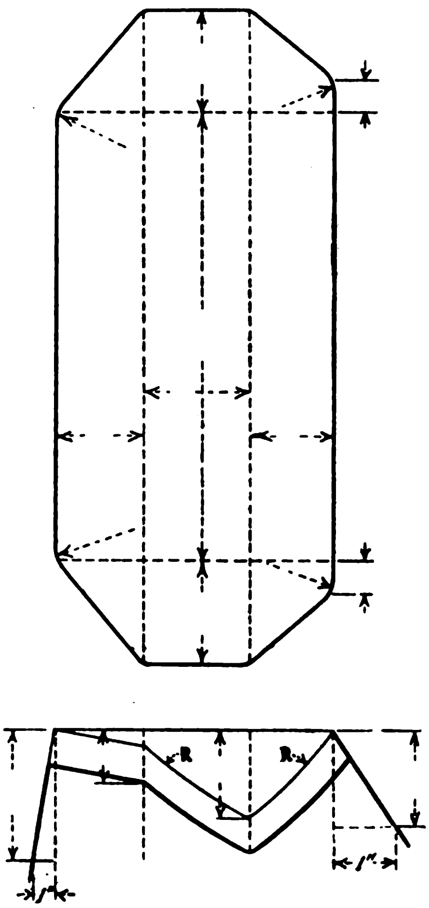


Fig. 20—Form of winding mold for coils with both sides above the throw line.

the bevels S and Q, the wire space, and the dimension F, which will be explained later. The dimension F, Fig. 11, is the distance EX of Fig. 7 less one-half the wire space or $EX-(WS \div 2)$, as shown in Fig. 7A.

The next step is to show how the B dimensions for the mold sketch in Fig. 11 must be corrected for coils that are to be wound in one operation and that have been laid out as indicated in Figs. 6 and 9.

Fig. 16 shows a single coil. The B dimension of the mold would be equal to AB on the throw line TL of Fig. 16, but the correct B dimension is CD; therefore, for single coils the B dimension can be made to the center lines of the slots.

Fig. 17 shows two single coils. The B dimension for a coil wound single would be AB; then for the single-operation mold, the B dimension should equal AD on the line TL of Fig. 17. This would give the finished one-operation coil the same correct B check as the wound-single assembled coil, unless the wound-single coil had been wound to the AD line. Then the one-operation coil would have to be wound to the CD di-dimension.

Fig. 18 shows three single coils wound with B equal to AB. For the one-operation mold, the B dimension should equal EF, or $AB-2d$, where d is the insulated diameter of one wire. If the wound-single B dimension were made to the correct B, as CD of Fig. 16, the one-operation B for Fig. 18 would equal CD.

Fig. 19 shows four single coils. If the wound-single B dimension were AB, the one-operation B dimension should equal AD; but if the wound-single B dimension had been equal to AD, as in Fig. 17, then the B dimension for the one-operation coil for Fig. 19 would equal CD.

Thus the method of winding the coil changes the B dimension on the mold; also, if the coil is laid out as in Figs. 6 and 9 and then changed to a one-operation, the dimensions H and N should also be changed.

When a coil is being designed, the advantage of the distance between points C and B on the throw line can be used or discarded according to the depth of the slot and size of wire, and the pull required to get the top half of the coil over and into the top slot.

When a mold sketch is being made from a sample coil, always use the inside B dimensions as CD for either the wound-single or the one-operation coil. If the sample coil has been wound satisfactorily, then the new coils should be exact duplicates.

Figs. 6 and 9 use the coil layout of one side above the throw line and one below, but in some cases when the point V in Fig. 11 of the mold breaks down during winding or when it is hard to get the mold apart, the coil can be laid out as explained. Then a line is drawn from point A, Fig. 9, to point C, or to the center line of

the bottom of the bottom half of the coil, thus placing both coil sides above the throw line. The dimensions *T* and *SK* must be scaled off, for they will be changed.

Putting both coil sides above the throw line also results in the straight part of the bottom slot section being equal to *A* less *R*, as in Fig. 11. The top of the bottom half of the coil would be longer than *A*, whereas with one cell below and one above the throw line, the bottom part of the bottom half of the coil would be shorter than *A* less *R*, the amount depending on the bevel *S*, the dimension *F*, and the wire space.

This falling away of the straight part, due to the compound angles, is important and should be checked, as the length of the straight part limits the length of the insulating cell that can be put on the slot section of the coil without wrinkling. On close designs, the placing of both cells above the throw line will insure maximum cell lengths in every case.

The above facts should be kept in mind when changing an existing coil that has been designed and wound on a mold with cells one above and one below the throw line to one having both above the throw line, as the dimensions *T* and *S*, Fig. 11, must be changed as well as the *B* and *H* dimensions. But angle *CDE* of Fig. 7 is more important. This should be checked, as changing the bottom cell to a position above the line will lengthen the top of the bottom cell, and if the coil angle was close before the change, the bottom coil ends will bind and prevent the coils from winding. A mold form arranged for coils with both cells above the throw line is shown in Fig. 20.

All the above points can be tried out on a sketch drawn to scale or by binding a heavy piece of wire and trying it in the armature. After a few trials, however, the layout will be found to be less complicated than it seems for the short-type coil.

Applications of Unit Heaters in Industrial Plants

(Continued from page 353)

stop and the heat from the radiator would then affect the thermostat and shut off the steam. In this way the unit automatically shuts off the steam at night when the fan is shut down, but in case the room should become cold would turn the steam on again and so prevent the unit from freezing.

Because of the thermostatic control of the steam line it is unnecessary to make any adjustments of the valves and no one is permitted to touch them during the heating season. Even though the steam is shut off when the temperature of the recirculated air gets above a certain point, the fan continues to circulate the air; thus any drop in temperature affects at once the thermostat and the steam valve. On this regulating unit it is not necessary to use a compressed air line because the thermostat is placed close to the valve it controls. If the thermostat were placed some distance away from the unit heater and controlled it according to the temperature at that point, it would be necessary to run a compressed air line to the unit to operate the valve.

Still another type of thermostatic control shuts off or turns on the motor driving the fan. This thermostat is placed at some distance away so that it would not be affected by the radiator in case the fan were shut off. A common type of such thermostatic control is known as the Mercoid (American Radiator Company) which makes and breaks a circuit through a mercury contact which is controlled by the temperature. Although these thermostats may be placed at some distance from the heater, it is merely necessary to run a control line between the thermostat and the motor circuit.

There are still other types of thermostatic control available, but in general they control either the power to the fan or the steam supply.

When unit heaters are to be installed in buildings, one of the principal points to consider is to so arrange the various units that as nearly uniform temperature as possible may be obtained throughout the room. This is best accomplished by having a number of units so arranged that they tend to set in motion all the air in the building or room. Unless the building is unusually long this can be accomplished by having all the units discharge so that they work in unison. That is, it is not advisable to have the fans discharge so as to "buck" each other by discharging toward each other. In such a case the cold air would be back of the fans and the warm air between the two. For example, in a long narrow room or building (if not too long) it would be better to place two heaters, about 20 ft. apart, near the center of the building, discharging in opposite directions. For an ordinary building it is usually well to have the discharge end of the heaters so placed that each will discharge toward the next and thus cause the air to circle the building. This is shown in the sketch on page 353. Also it is well to direct the discharge of at least one of the heaters toward the worst exposure.

If the building is more than 15 ft. in height and overhead heaters are used it is sometimes advisable to arrange to take from the floor line the air which is blown over the heaters. This procedure heats the coldest air by removing it from the floor and causes the warm air to be sent to replace the cold air removed. If, however, the building is not very high it is generally not necessary to do this. Frequently the same results are obtained by using a deflector which tends to turn the warm air down toward the floor. However, the deflector should always be placed so as not to direct the air toward workers.

In general, more uniform and satisfactory results are obtained by installing a number of smaller units rather than one or two large ones. Greater economy of operation is also possible, because in mild weather fewer heaters need be used to maintain a uniform temperature. With only one or two large units this cannot be done. Furthermore, if only one or two large units are used, the air returning to them at times creates an objectionable draft around the unit. Practically all manufacturers of unit heaters make a variety of sizes so that with any type selected it is possible to choose a suitable size, with the largest sizes reserved for very large buildings.

NOTE: Acknowledgment is made to the following companies for information and illustrations used in this article: American Blower Co., Detroit, Mich.; Autovent Fan & Blower Co., Chicago, Ill.; Bayley Mfg. Co., Milwaukee, Wis.; The Buckeye Blower Co., Columbus, Ohio; Buffalo Forge Co., Buffalo, N. Y.; Clarage Fan Co., Kalamazoo, Mich.; The Herman Nelson Corp., Moline, Ill.; Ilg Electric Ventilating Co., Chicago, Ill.; Modine Mfg. Co., Racine, Wis.; The Powers Regulator Co., Chicago, Ill.; Skinner Bros. Mfg. Co., Inc., St. Louis, Mo.; L. J. Wing Mfg. Co., New York, N. Y.; and York Heating & Ventilating Corp., Philadelphia, Pa.

Oversights That Cost Money

Here is an example that may easily be overlooked by you, but not by the railroad

THERE are times when all of us have wished we could be set back ten or twenty years and have the opportunity to do certain things over again in the light of experiences that have brought a fuller knowledge or understanding of our work. When we get into this mood, it is a good time to sit down and put on paper the corrective thinking that we can now apply to a particular problem. The reason for doing this is not so much to get a printed record of it as to make it available to others who must certainly travel paths similar to those we have traveled and be forced, as we were forced by circumstances or lack of knowledge and experience, to make mistakes that could have been avoided.

EVERY superintendent who has spent fifteen years or more in plant work knows that it is a most difficult job to find a ready-made assistant, and realizes what a long and patient job it is to train one. The experiences of you men who have successfully done this job would be most valuable information for the young operator who aspires to a position at the head of a large shop or organization. Things to do and not to do, including the handicaps to overcome in misdirected ambition, jealousy, and temper, are also possible subjects. But most helpful of all would be a discussion of the things that are expected of a young man who has the ability and make-up to carry successfully the title of plant superintendent. This information in the form of actual experiences on a particular job would be welcome as articles for publication.

I RECALL a recent conversation with a superintendent who complained bitterly about the carelessness of an assistant in regard to a purchase on which there had been unnecessarily heavy freight charges. This shipment was a single-width, single-inlet ventilating fan that was too large to go through the door of a standard box car. These doors are 7 ft. 6 in. high by 6 ft. wide.

THE fan weighed only 3,900 lb. but because of its size it came under Rule 29, Section 3 of the Consolidated Freight Classification No. IV, and the freight was considerably more than it would have been had the fan been ordered shipped knocked down instead of assembled.

The difference in the amount of the freight was not the subject of complaint; it was the fact that the young man had not thought to order the fan knocked down, for he knew that when assembled it could not be taken to and installed in the space provided for it. It is probable that he will not make this mistake again. The reason for it was that he was too busy thinking about the job for which the fan was to be used, to stop and think over the best way to ship it, that being considered a manufacturing problem and not an operating problem.

THIS one incident may recall many others of a like nature to you men who have been most of the way through the mill. In this connection just remember that it's our job to make successful foremen and department heads just as well and successfully as we make pig iron, plowshares, automobiles or what not. Think about this and out of your experience send me something that will help to keep the young operator from making the mistakes we did and, incidentally, save the expense that many of them cost us in money, time, and humiliation.

Practical Pete

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories
Published by McGraw-Hill Publishing Company, Inc.
G. A. VAN BRUNT, *Editor*

New York, August, 1927

Standards for Industrial Gears Are Now in Sight

THE American Gear Manufacturers Association has undertaken a constructive program of standardization that will be of benefit to every industrial operating man.

At the present time difficulty is often experienced in ordering or making a duplicate gear or pinion, especially when it is not possible to obtain this from the original manufacturer who is able to refer back to his drawings for the proper dimensions. Much of this trouble is due to the various so-called "standards" in vogue during the past few years. Many of these standards are in reality shop practices and altogether too often each shop established its own practices. Although many of the differences in standards are on minor points, thev have considerable effect upon matching the gear or pinion with its mate.

Trouble of this nature will be eliminated, particularly in the case of gears made in the future, by the work that is now being done by this association, whose members represent many of the largest manufacturers of industrial gears.

In addition, studies are being made of the permissible gear tooth loads, with particular attention to the high speeds of modern industry and the newer non-metallic gear materials. Work of this nature is of much importance to gear users. The old formulas for gear design were based on data collected when gears were not subjected to the speeds and loads that are common in present-day practice.

The activities of the American Gear Manufacturers Association in behalf of gear users are highly commendable.

Tell Us How You Have Solved Your Power Drive Problems

IN NEARLY every industrial plant of any size there are one or more power drives that cause an excessive amount of trouble. Operating conditions may be unusually severe, the drive may have been poorly laid out, the equipment improperly installed, or a variety of other causes may have operated to produce a drive that has always been unsatisfactory and troublesome.

Oftentimes, by the exercise of some ingenuity and possibly with the assistance of some manufacturer of power drive equipment, the plant man succeeds in overcoming the trouble and works out a drive that operates satisfactorily.

In many other instances the correct answer to the problem has not yet been found, and an inefficient, troublesome drive is being nursed along and kept going largely by "main strength and awkwardness," as the saying is.

There is no particular rule or formula that can be applied to the solution of such power drive problems. Each case must be studied individually, and all of the conditions and requirements analysed and evaluated. If it is possible to make any of the operating conditions less severe, this should be done. In any event, it is safe to assume that there is available a sufficient variety of power drive equipment, and enough experience and information regarding its application, to solve any operating problem in a satisfactory and economical manner. It is, however, necessary to use this information intelligently, and in the light of a definite knowledge of all pertinent factors bearing on the drive in question, in order to make sure that the combination of equipment employed is the best and most efficient for the application.

The Editors of INDUSTRIAL ENGINEER are making a detailed study of difficult and unusual drives, the results of which will be reported in an early issue. Operating men who have satisfactorily solved some difficult power drive problems, or who are still trying to do so, are invited to send full details to the Editors.

When Fewer Men Do More Work

MOST of us remember such school-day problems as, "If ten men can do a job in thirty days, how long will it take thirty men to do it?" According to the answer given in the back of the book, the thirty men would finish up in ten days. However, many industrial plant men have learned that when they tried to work this problem out with men the answer is more likely to be twelve or fifteen days, instead of ten.

This apparent discrepancy does not prove that the laws of arithmetic are variable. It does show, nevertheless, that the problems incidental to handling men and work are variable. The reason for this variation is generally to be found in the ability of the man who is responsible for selecting the workmen and overseeing their work, rather than in the ability of the men themselves.

An interesting example of this was recently shown in one industrial plant. The machinery, lineshafts, motors, and other equipment had to be installed in a new building. To speed up the job about fifty new men were hired, and five of the ten

men composing the regular crew were put in with the new men.

The man in charge had always looked closely after details and handled his small force well. With the big addition to his crew he still tried to do all the supervising himself, as he had no one capable of acting as assistant foreman. As a result he soon found himself swamped. Everyone waited for instructions, and in many cases did not take the trouble to hunt him up, but waited, sometimes for several hours, until he came around. Thus many of the men were practically idle a considerable part of the time.

The force was eventually cut about in half. With the smaller number of gangs supervision was comparatively easy; in consequence more work was done.

Although construction and maintenance work in many plants is suffering from lack of enough men to handle it properly, little is gained by hiring more men than can be given adequate supervision. When unusually large jobs are to be handled much more can usually be accomplished by carefully planning and directing the activities of the regular force, with perhaps a few extra helpers, than by adding more men than can be given such careful supervision.

Motor Troubles with Short-Center Belt Drives

CONSIDERABLE liberty is too often taken with good operating practice for center distances when leather belts are used. When motors of 5-hp. rating and larger are installed with pulley centers of less than 10 ft., and no provision is made for the use of special belt tighteners, motor troubles can be expected sooner or later. This is particularly true if the motor operates continuously close to its full-load rating.

In the first place, when centers are too short and the motor pulley is of the standard diameter, say 4 or 5 in., the contact surface is too small to allow the driven machine to be accelerated as fast as a squirrel-cage motor comes up to speed. As a result the belt slips off. This is usually taken by the operator as a signal to tighten the belt, and then real trouble begins.

Excessive belt tension wears down bearings, causes the motor to run hot and will probably blow fuses. If magnetic switches are used the overload relays will trip and give some thoughtless operator, who knows little about these switches, an excuse to adjust the relays beyond the safe setting for motor protection.

The result of all this procedure shows up finally in burned-out bearings or windings, or both—and in most cases it is both. In either instance, the cost of repairs to bearings or windings will be much more than the extra cost of a belt of the proper length and width to handle the motor load.

No single piece of equipment in a plant will stand more abuse or give longer and better service than a good leather belt, but abuse of belts in narrow widths and single-ply weights on short centers can never be excused.

If there are any short-center belt drives in your plant at this time we suggest that you inspect the record of motor repairs for such drives. If any one motor that is not overloaded has a rewind job charged to it, change the belt to the width and length that standard handbooks give as good practice for belt drives.

Overcome Conditions That Limit Production

FOR every industrial operation there is a practical limit which determines the quantity, cost, time, or other economic factors in that operation. Material handling is one of the best examples of the importance of this practical limit, and incidentally provides numerous instances where this limit has been studied and increased to considerable economic advantage.

For example, wire-drawing operations were in the old days generally limited by the weight a man could handle. When hoists, alone or in combination with conveyors, were adopted the limitation imposed by the strength of the operator was reduced so that larger rolls meant less frequent and shorter stops, and less waste.

Problems incidental to handling bulky but light products, where the size or bulk established the handling limit, were overcome by the use of special carriers which were large enough to take a greater number of the bulky units at a time. The use of special grappling devices for lifting or holding, yokes for non-magnetic materials and magnets for handling iron or steel products, increases the unit load and also decreases the time required for picking up and putting down a given quantity of material. A truck that can lift, carry, and pile, or handle 2 tons at a time instead of only 1, is also reducing the cost of production by decreasing the former limitations.

Many other instances where a hoist, conveyor, truck, or other piece of material handling equipment, or specially designed attachment for such equipment, has gone beyond the limit of muscle power, or replaced other equipment of limited capacity, could be enumerated.

Every operating man has the opportunity to suggest and put into practice new ideas that will not only remove limitations to production but reduce production costs as well. The cost of handling is not only an important element of production costs, but is frequently one of the easiest to reduce.

QUESTIONS

Who Can Answer These?

Protecting Small Transformers From Shorts and Overloads

We use several small 110-volt transformers for operating our bell and annunciator circuits. These transformers frequently burn out, apparently from short circuits or overloads. If fuses are used to protect these transformers, should they be placed in the primary or secondary circuits? Is there any better way of protecting the transformers? It may be that readers can tell me of a more dependable method of supplying the necessary current. R. S. T.
Worcester, Mass.

Charging Storage Batteries From Exciter

In our plant we have a combination signal and fire alarm system operated from three 6-volt, lead batteries connected in series. Instead of sending them out every month, I want to charge them from the 125-volt exciter on our generator, which is in continuous service. In order to lower the voltage for charging I want to use a number of spare cast-iron grids that are kept on hand for a 50-hp. motor. Will readers, therefore, suggest a method of determining the resistance per grid, so that I can determine how many to use? R. C. B.
Grenada, Miss.

Determination of Motor Rating for Capstan

We wish to haul our department trucks at a speed of 2 miles per hour up a concrete ramp that is 40 ft. long and has a pitch of 30 deg. These trucks, which have a loaded weight of 900 lb., have rubber-tired wheels. The hauling is to be done by a capstan located at the top of the ramp. I wish readers would tell me how to determine the proper size and speed of 550-volt, three-phase a.c. motor, size of capstan drum and reduction gear ratio that should be used for this job.
Altoona, Pa. G. M. E.

Cause of Low Voltage On Exciter

Our company recently installed a 250-kw., three-phase, 60-cycle, 440-volt, 328-amp., belt-driven generator. It is separately excited by a 23-kw., 125-volt, 183-amp. compound-wound generator, which is driven by a belt from the a.c. generator shaft. The exciter heats badly, and will not build up a voltage over 100. In order to maintain the 440-volt line voltage, it is necessary to operate with one rheostat wide open and one completely closed. Will readers please tell me what is causing my trouble? J. J.
St. Mullins, S. C.

Driving Lineshaft By Two Motors

Several machines are operated from one lineshaft in our mill. On some days the load on this shaft is 15 hp. while on others it is 50 hp. We have two 25-hp., constant-speed, shunt-wound motors on hand, and wish to connect them to the shaft through clutches. When the load falls below 25 hp., one motor can be shut down. Will readers tell me (1) whether these motors will operate properly if connected to the same shaft? (2) Is this plan feasible? (3) Is it possible to operate in this manner two constant-speed compound-wound motors, two series motors, or two adjustable-speed, shunt motors? E. K.
McKeesport, Pa.

Emergency Lighting from Current Transformer

We have a 440-volt motor in service at a considerable distance from the 110-volt lighting system. In the one phase of the motor circuit there is a 20:5-amp. current transformer for operating overload trips. Inasmuch as we do not want to extend the lighting system for only one lamp, and do not wish to install four lamps in series, will readers tell me whether I can cut a lamp in the secondary circuit of the current transformer? If so, what size and type of lamp should be used? A. K. R.
Superior, Wis.

Motor Current Increases When Neutral Is Connected

We have a three-phase, four-wire, 60-cycle, 4,000-volt, 21.7-amp., 185-hp., 900-r.p.m. unity power factor synchronous motor direct connected to a 440-volt a.c. generator. Running without load at unity power factor and with the neutral disconnected, the current in each phase is 2.4 amp., but when the neutral is connected 30.5 amp. flows in the neutral and 10.32, 10.5, 10.5 amp. flows in phases A, B, and C, respectively. Although this motor has given similar trouble on another line, there are other four-wire, 4,000-volt, Y-connected synchronous motors operating successfully on this circuit that has a power factor of 98 per cent lagging. The field coils in this motor are in first-class condition. Any suggestions from readers that will enable me to remedy this trouble will be appreciated.
Ft. Wayne, Ind. J. L. D.

ANSWERS

Received to Questions Asked

Advantages of Three-Phase, Four-Wire System

As there seems to be an increasing use of three-phase, four-wire systems, I shall appreciate it if some reader will answer the following questions. What are the principal advantages of a three-phase, four-wire system over a three-phase, three-wire system? Are there any special conditions under which these four-wire systems should or should not be used? Can three-phase, three-wire, watt-hour meters be used to measure the current consumption in three-phase, four-wire systems? R. L. P.
Pittsburgh, Pa.

ANSWERING the question by R. L. P., the general advantages of a three-phase, four-wire system are as follows:

(1) Increase in the transmitting voltage with the attendant ability to transmit more energy over the same size of conductors without changing the voltage of the transforming equipment. As the energy transmitted varies as the square of the voltage for the same percentage loss, a change from a 2,300-volt, three-wire system to a 4,000-volt, four-wire system would increase the carrying capacity of the same circuit in the proportion of $4{,}000^2 \div 2{,}300^2$ or about three times. As previously stated, no change is needed in the voltage of the transforming equipment, and by changing the connection from delta to star on the side in which the voltage is changed, the desired result is readily obtained.

(2) The ability to ground the neutral point of the four-wire or star-connected side and assure a definite maximum voltage between any transformer winding and ground.

A possible disadvantage of the three-phase, four-wire system may be outlined as follows:

With a grounded neutral, a ground on any of the other lines would result in a short circuit. If the lines were carried through trees or in a conduit

subject to dampness, this would mean frequent interruptions and excessive maintenance. This possible disadvantage, however, is offset by the fact that while this system requires more careful attention, the increased efficiency will result in better operation and less maintenance. As a matter of fact experience indicates that there are fewer troubles with a three-phase, four-wire grounded system than with a straight three-wire ungrounded system, although when the change is made from one to the other there must be a complete and thorough overhauling of the existing system.

The metering of energy on a three-phase, four-wire system can be done as follows:

(1) By using three single-phase meters with three current and three voltage transformers.

(2) By using two single-phase meters or one three-phase, three-wire meter with three current and two voltage transformers.

(3) By using a special three-phase meter with two voltage and three current transformers.

(4) Under exceptionally well balanced circuit conditions, a three-phase, three-wire meter or two single-phase meters with two current and two voltage transformers may be used.

The foregoing methods are all in general use, No. 1 being the most accurate, while Nos. 2 and 3 are very nearly on a par and No. 4 is not at all accurate under any except the most ideal circuit conditions.

The connections for the various methods of metering are shown in the accompanying diagrams, the numbers corresponding with the above paragraph numbers. These connections show the general conventional connections but without regard to any definite polarity. In Fig. 2 a three-phase, three-wire meter is shown, although two single-phase, two-wire meters may be used. The same comment of course is true if two single-phase meters are used.

As a matter of fact, the methods given in Figs. 2 and 3 are very often used.

If R. L. P. is interested further in the matter of metering three-phase, four-wire circuits, he will find valuable information in a bulletin (No. 9, Vol. IX, Bulletin No. 13) issued by Purdue University, Lafayette, Ind., in December, 1925, as a publication of the Engineering Departments.

C. OTTO VON DANNENBERG.
Electrical Division,
General Engineering &
Management Corp.,
New York, N. Y.

These diagrams indicate various methods of measuring power in a three-phase, four-wire system.

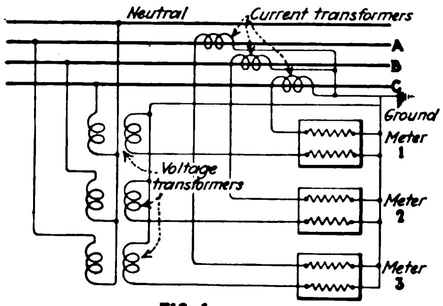


FIG. 1

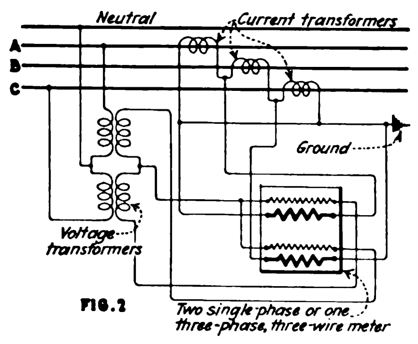


FIG. 2

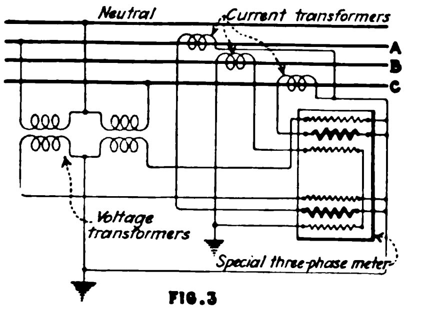


FIG. 3

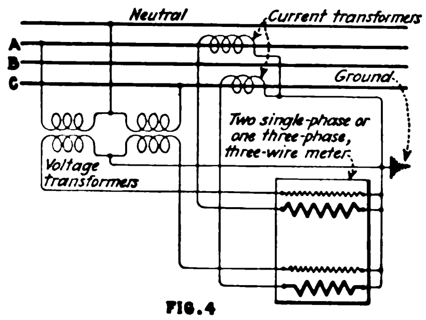
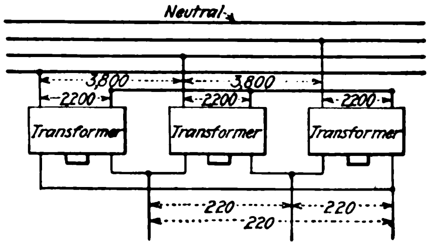


FIG. 4

IN ANSWER to R. L. P.'s question, in a three-phase system two connection schemes are commonly employed; the delta connection, and the star or Y connection. The terminals of a delta-connected system naturally supply a three-wire circuit, whereas the terminals of a star-connected system can supply either a three- or four-wire system, the fourth wire being connected to the neutral point at the center of the Y.

The three-phase, four-wire system has several advantages over other systems. When the load is approximately balanced, power is generally transmitted at 3,800 volts, and the feeder drop is only about one-half of what it would be on a single-phase feeder under similar conditions. The transformers are connected from phase wire to neutral for lighting service, and are star-connected for power service, so that standard 2,200-volt, single-phase transformers may be used for both light and power.

The line construction is no more expensive than for 2,200-volt circuits, although more precaution must be taken to guard against grounding of phase wires, because the neutral wire is grounded and any accidental ground on a phase wire will cause a short circuit. However, a ground on one phase does not interrupt lighting service on the other two phases, as the neutral wire takes up the return current if one phase becomes open.



This diagram shows how transformers are commonly connected to a three-phase four-wire system for 220-volt service lines.

The voltages on the different phases may be regulated independently and an unbalanced load does not interfere with regulation, as the return current is taken care of by the neutral wire. A 3,800-volt, four-wire system with the neutral conductor of the same size as the phase wires requires one-third the weight of copper in feeders that is required by a single-phase or a two-phase, 2,200-volt system, or 44.4 per cent of the weight of copper required for a 2,200-volt, three-phase, three-wire system. Part of this saving in the feeder system, however, is offset by the cost of the fourth wire.

The usual connections for three-phase, three-wire service at 220 volts from 2,200-3,800-volt, four-wire, three-phase mains are shown in the accompanying illustration. Here in order to give the required secondary voltage the primaries are Y-connected and the secondaries are delta-connected.

Energy consumption in a three-phase, four-wire system can be measured by three single-phase watt-hour meters, by a special two-element polyphase meter or by a three-element polyphase meter. Either the first or the third method is used when the phase voltages are badly unbalanced. HORACE TURVILLE.
Lansdale, Pa.

ANSWERING R. L. P.'s question, he should use a three-element meter for a three-phase, four-wire system instead of a two-element meter as used on three-phase, three-wire systems.

In primary distribution this system is usually operated at 3,800 volts between phase wires, and 2,200 volts between any phase wire and neutral. This gives the advantages of 3,800-volt distribution in the feeder system, and permits the distribution of energy over a radius about twice as great as with 2,200-volt transformers. The unbalanced load is carried by the neutral wire, and by the use of line-drop apparatus, good pressure regulation is possible with any proportion of unbalanced load within the rated current limits of the line.

The four-wire distribution mains are carried only where there are motors or large loads to be served; only three wires are needed for installations of

less than 30 to 40 hp., which may be served by two transformers connected in open delta. JOHN W. BANTAU.
Los Angeles, Calif.

REPLYING to R. L. P.'s question, I would say that the advantages of three-phase, four-wire systems are: Greater transmitting distance with the same resistance loss; smaller feeders or conductors can be used, due to a higher primary voltage, which increases line capacity and decreases primary amperage; and standard commercial 20 to 1-ratio transformers can be used.

Usually 4,000 volts are carried on three-phase, four-wire systems, and in cases of mixed and unbalanced loads the three phases and neutral should be used in connecting the transformers, as the neutral compensates for the unbalanced conditions in the feeders of local distribution.

Three-phase, four-wire systems are sometimes used to take care of large power installations that are a considerable distance from the feeding station, but only the three-phase wires are used at the power bank due to the fact that if the neutral is connected to the power bank, and one phase fuse fails, the two transformers would then carry the entire load, in which case they would likely be burned out.

Between this power installation and the station, single-phase, local distribution systems can be connected, using one phase wire and the neutral. One important fact in regard to three-phase, four-wire systems is that at the station there should always be installed one current transformer and one relay in each phase. This will afford safe protection on all three phases of the four-wire system. On three-phase, three-wire circuits usually only two current transformers and two relays are used. If this practice is followed on feeders that supply the four-wire system, the middle phase will be unprotected.

Three-phase, four-wire systems can be metered by using a standard three-phase, two-element watt-hour meter in conjunction with three current transformers and two potential transformers.
Meter Foreman, C. W. ROSELLE.
Illinois Power & Light Corp.
Galva, Ill.

IN REPLY to R. L. P.'s question, the three-phase, four-wire system has the same advantages over the three-phase, three-wire system that the latter has over the single-phase system. Also, there is a saving in copper that is slightly greater between the first two systems than between the latter two.

With the three-phase, four-wire system, two potentials are available. The same potential exists between each phase wire and the neutral, and there is 1.732 times this voltage between phase wires. To make this point more clear, in a three-phase, four-wire circuit having 4,000 volts between each phase wire and neutral, there is 4,000 $\times$ 1.732 or 6,928 volts between the phase wires. With this additional potential, a greater transmission radius may be served without undue line drop. For metering, a three-phase wattmeter may be used with three current transformers, and good results can be obtained under all load conditions, providing the potential is constant during any unbalancing in the circuit.

The usual practice is to utilize three single-phase watt-hour meters, connecting one meter in each phase wire, the potential leads being connected between the respective phase wires and the neutral. The sum of the three meters indicates the total energy consumed.

There is also a three-phase, four-wire meter having four series and shunt coils. Two series coils are connected in series for the middle phase wire; the other two series coils are separate, one being connected in each outside phase wire. E. J. ELVISH.
Maintenance Inspector,
Kaministiqua Power Co., Ltd.
Fort William, Ont., Canada.

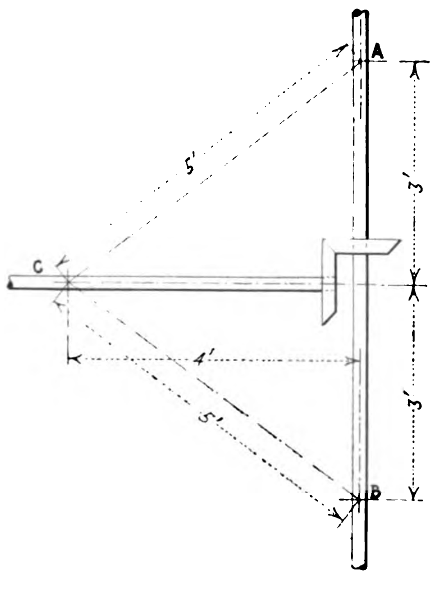
Testing Alignment of Right Angle Shafts

**I wish some reader would help me out with some suggestions on a method of testing two shafts mounted at right angles and connected by bevel gears. The short shaft with the bevel gear consists of two 16-ft. sections of $2\frac{3}{16}$-in. shaft. The main $2\frac{13}{16}$-in. shaft is 60 ft. long. I am having trouble due to wear of the bevel gears and think that it is due to misalignment. What is the best way of checking this right angle? Also, how can I be sure that the two shafts are at the same level? E. H. G.
Cleveland, Ohio.**

I BELIEVE E. H. G. will find that the old reliable method of checking angles and leveling lineshafts, that is generally referred to as the 3-4-5 or 6-8-10 rule for right angles, and the use of the water level for leveling, will be very satisfactory.

The first step in solving E. H. G.'s problem would be to check the right angle. The accompanying sketch shows how this may be done. The method is the same whether the shaft extends to the right or to the left, or both, as in the sketch. In case the shaft does not extend through, the triangle can be erected at one side only. First, points A and B are measured 3 ft. from the imaginary intersection, X, of shafts. Point C is located 4 ft. from X at right angles to the main shaft, which has already been measured out a distance of 3 ft. The distance from C to A or C to B, or the hypotenuse of the right-angled triangle is exactly 5 ft.; the right angles formed are A-X-C and B-X-C. If desired, and pulleys do not interfere, the longer dimensions of 6 and 8 ft. with 10-ft. hypotenuse can be substituted for the smaller dimensions. Any multiple of 3, 4, and 5 such as 12 and 16 ft., with 20 ft. hypotenuse, can also be used. The natural result of using longer dimensions is more accuracy if the measuring devices are accurate and the measurements carefully made.

Method of checking a right-angle shaft with bevel gears by the 3-4-5 method of triangulation.



In leveling two lineshafts an ordinary hose filled with water can be used. To make this more convenient and accurate, gage glasses are inserted in the end. The hose should be filled with water, the two ends placed side by side, and the water level marked on each. This will permit much closer readings of the level.
Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.,
Aurora, Ill.

REFERRING to E. H. G.'s question, the procedure I would advocate requires that first of all two lines be laid off on the floor directly under the shafting. To do this, plumb down to the floor from two points on each shaft.

After doing this, extend the lines drawn through these points until they intersect. From this point of intersection measure off on one line some distance in feet, say 3, 6, or 9 ft., that is a multiple of 3.

Then measure off on the other line from the point of intersection a distance that is 4 times the multiple of 3 used in determining the distance on the first line. Now if the shafts are at right angles the distance between the two points just established should be 5 times the multiple of 3 previously used. If the points are not exactly this distance apart, it will be necessary to alter the alignment of one shaft, selecting, of course, the shaft that is easiest to swing.

In order to establish the new position of the shaft to be moved swing an arc having a radius equal to the distance laid off on the shaft to be moved. While swinging the arc use the old intersection of the shaft lines as the center of one arc, and the point established on the other shaft line as the center of the other arc. The point where the two arcs intersect will determine the new location of the shaft to be moved.

When leveling the two shafts apply the level at two different places, to verify the levels. To account for the difference in levels between the tops of

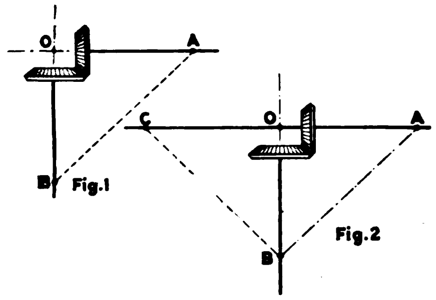
the shafts an allowance of (2-15/16 — 2-3/16) ÷ 2 = ⅜ in. must be made at the smaller shaft.

Trouble with bevel gears may come from their not being properly meshed, either in depth or endwise. Also loose collars or poorly braced hangers, which allow the teeth to force the gears apart under load, may cause trouble.

H. D. FISHER.
Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

IN REPLY to the question by E. H. G., I find it best to check the shafts first with a good spirit level before proceeding to check the angle between the shafts.

One method of determining the right angle between two shafts involves the



These diagrams indicate the respective positions of points to be used in checking a right angle between shafts.

Pythagorean theorem, that the sum of the squares of two sides of a right angled triangle is equal to the square of the hypotenuse. Thus, the method of procedure, as outlined in Fig. 1 in the accompanying illustration, is as follows: According to the above theorem $(OA)^2 + (OB)^2 = (AB)^2$. The point O is where the shafts through the two gears would meet if they were extended. Points B and A should be marked with a center punch on the top center line of each shaft. For example, suppose OB is laid off 100 in. and OA is 120 in. Then $BA = \sqrt{(100)^2 + (120)^2} = \sqrt{10{,}000 + 14{,}400} = 156.25$ in., approximately. These dimensions must be carefully laid off with a wire or steel tape, something that will not stretch.

In the second case, as illustrated in Fig. 2, no calculations are necessary. Proceed by marking the point O where the center line of both shafts would meet if the shaft marked by point B were extended. Then mark points C and A making $CO = AO$, or about 6 ft. If the two shafts are at right angles, CB must exactly equal AB.

R. B. TURNER.
Manager,
Johnson-Turner Electric Repair & Engineering Co.,
Walkerville, Ont., Canada.

REPLYING to the question by E. H. G., the right angle between two shafts can be checked by measuring the distance between two points, one on each shaft, each point being determined by measuring off a certain distance from the point that would be established if the shafts were extended so that they intersected. The distances laid off on the shafts can be called the legs of a right-angled triangle. The length of the hypotenuse or distance between the two points established on the shafts can be determined by recalling the old rule of 6-8-10, where 6 and 8 represent the legs of the triangle and 10 the hypotenuse, or the distance between the two points established on the shafts.

As the shafts are not of the same diameter, an allowance must be made at the smaller shaft when using a level between the two shafts. That is, an allowance of (2-15/16 — 2-3/16) ÷ 2 = ⅜ in. should be added to the top of the smaller shaft.

E. N. DILLARD.
Chief Electrician,
Booth Kelley Co.,
Springfield, Ore.

ANSWERING E. H. G., he will find that a good, practical method whereby right-angle shafts may be accurately aligned is as follows: Suspend plumb bobs or weights from fine silk threads over the shaft as shown in Fig. 1 at points A and B, or at similar convenient points along the line EG, in Fig. 2. When the plumb bobs have ceased swinging establish a horizontal silk thread line AG, so that the horizontal thread just touches the vertical threads A and B.

Similarly, drop silk threads from the shaft at right angles with the first at points C and D and establish a second horizontal silk line HF. From the point of intersection F measure off convenient distances FE and FG, both of which must be exactly equal. Then from an equal or almost equal distance HF, measure the distances HE and HG. If HE is exactly equal to HG the shafts are at right angles. The reason why, I believe, is perfectly obvious.

Figs. 1, 2 and 3—Method of checking alignment of right-angle shafts by triangulation and the use of plumb bobs.

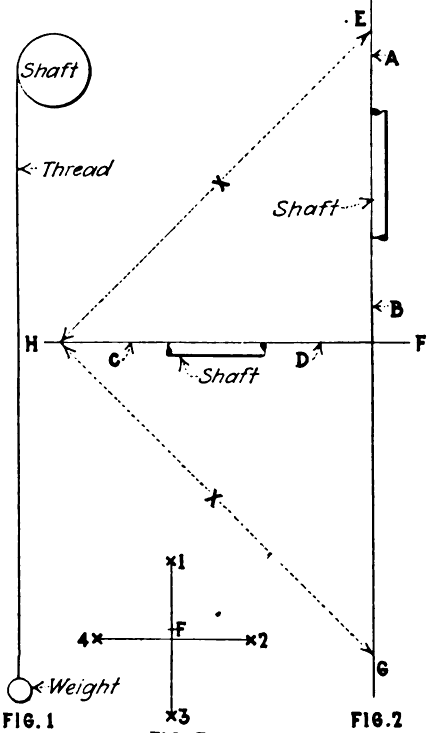


FIG.1 FIG.3 FIG.2

The light, silken threads will deflect somewhat even though pulled taut. The horizontal silk lines should be perfectly horizontal, and on the same level. This may be accomplished so that the measurements will be accurate by locating the suspension points at equal distances from the point of intersection F as shown in Fig. 3. Point F in Fig. 3 is the same F as in Fig. 2, but Fig. 3 is drawn to a much smaller scale to show the suspension points. Thus, $1F$, $2F$,

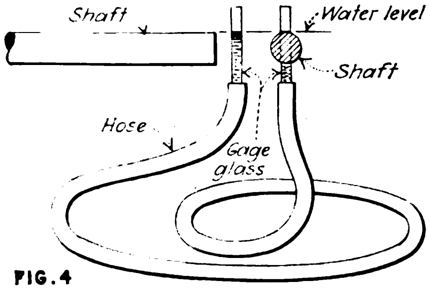


FIG.4

Fig. 4—Use of water level in checking level of shafts.

This level, which consists of a hose and two pieces of gage glass, can be used to level each shaft after the right angle is established, and also to check whether the two shafts are in the same horizontal plane.

$3F$, and $4F$ are all equal in length: hence the deflections of each will be the same with the same tension in both threads.

There are a number of good ways in which right-angle shafting may be leveled accurately. One way involves the use of an ordinary garden hose filled with water, with gage glasses inserted in the ends as indicated in Fig. 4. No matter how far the ends of the hose are apart, the water will always assume a perfect level and the observer can make sure that the shafting is absolutely level at all points. This method is useful not only for leveling shafting but for laying foundations for machines and buildings, and even for laying large floors.

When employing the hose method the millwright must be certain that there is no air in the hose and also make sure that one end of the hose, after filling with water, is not heated to a higher temperature than the other end. It is evident that an air pocket will cause a false level; also, if one end is heated, the density of the water in that end will be less and consequently the level will be higher.

The best method of all, when leveling and aligning shafting, is, I believe, to use a special adaptation of surveyor's instruments that are on the market for that purpose. However, these instruments are rather expensive for small plants that do not have much shafting

to align. For small jobs the method outlined herein will be found perfectly satisfactory when done with care, and it can be done quickly.

W. F. SCHAPHORST.

Mechanical Engineer,
Newark, N. J.

Effect of Commutating Poles on Magnetic Field

I have noticed that some of our d.c. interpole machines are equipped with one commutating pole per pair of main poles, while others have one commutating pole for each main pole. In cases where one commutating pole is used per pair of main poles, is there any unbalancing in the magnetic field that will cause cross armature currents? Readers' opinions will be appreciated. W. M. P.
Seattle, Wash.

ANSWERING W. M. P.'s question, the object of using interpoles is to reduce sparking at the brushes. This is accomplished by providing an auxiliary flux or commutating field at the point where the armature coils are short-circuited by the brushes. The action of this commutating field is to help resist the current in each coil while it is short circuited by the brushes, thus reducing sparking.

The interpoles produce a magnetic field, which in turn causes the current in the field coil under commutation to reverse and build up in the opposite direction. If the field in this case is too weak, the reversal will occur too late, and there will be sparking. If it is too strong, the reversal will come too early, with the result that the current will then build up too high and will have to be suddenly reduced as the commutator bars pass out from under the brush. Under this condition, there will also be sparking.

Each interpole on generators should have the same polarity as the pole that trails it, in respect to the direction of armature rotation, but in motors the interpoles should take the polarity of the pole that precedes them. If the machine has four main poles, it will still operate satisfactorily with only two interpoles.

For a wave-wound armature, it is not necessary to use more than two brushes, regardless of the number of poles used, but generally it is advisable to use more than two brush positions with wave windings, especially when the current is very large.

H. J. ACHEE.

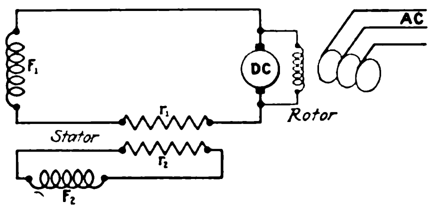
Superintendent,
City Water & Light Dept.,
Woodward, Okla.

Characteristics of Fynn Weichsel Motor

I shall appreciate it if some reader will explain in non-technical terms the characteristics, construction, and principles on which the Fynn-Weichsel motor operates. Is it necessary to use special control equipment with this motor?
Lansdale, Pa. H. T.

ANSWERING the question by H. T., the Fynn-Weichsel motor is a synchronous-type motor in so far as its operating characteristics are concerned. When the motor is operating in synchronism, the power factor is leading and the amount of leading power factor depends, of course, upon the amount of excitation supplied to the motor. The operation and characteristics of the motor are best explained by referring to the accompanying diagram.

In this it will be seen that the rotor carries three slip rings, and also a direct-current commutator. The primary alternating-current power at 220, 440 or 550 volts is applied to the slip rings. The stator consists of two phases of windings that are wound 90 electrical deg. apart, and distributed around the circumference of the stator. One of the stator windings, F_1, is connected permanently in series with the brushes that take off direct current from the commutator of the rotor. Incidentally, the amount of direct-current power is about four per cent of the total power imput to the motor, and, of course, is very



This diagram shows the connections of the windings of a Fynn-Weichsel motor.

small. The other winding, F_2, which is wound 90 electrical deg. from winding F_1 is short circuited upon itself when the motor is operating in synchronism. This is accomplished by means of a simple resistance-type starter that short circuits the resistance r_1 and r_2.

When the motor is started, all resistance is in each of these two circuits, in series. As the handle of the starter is moved over, the resistance is cut out until finally winding F_1 is in series with the d.c. commutator, and winding F_2 is directly short circuited upon itself. Of course, the direct-current winding supplies alternating current until the motor reaches synchronous speed. The frequency of the current, however, is decreasing as the speed of the rotor increases. When the slip has become very small, the direct-current commutator is carrying a very low frequency of alternating current, approximately two or three cycles per second. This low frequency alternating current assists the motor in pulling into step, or synchronizing itself, after which the current is direct current only. Winding F_2 then acts as a damper winding, and prevents the rotor from oscillating back and forth, which is called hunting.

The construction of the motor is very similar to that of a slip-ring motor with the addition of a small commutator, usually on the end opposite the slip rings, although on the smaller sizes the slip rings and commutator are on the same end of the rotor. The stator windings are quite simple, consisting of two series windings with the concentric-pole tyne of coil. The windings on the rotor are the regular three-phase a.c. windings, together with the small, direct-current windings used for exciting purposes.

The control equipment furnished with Fynn-Weichsel motors consists of the primary magnetic switch, which is equipped with undervoltage and overload protective devices. This switch is interlocked with a simple resistance starter that is inserted in the secondary circuit, F_1 and F_2. The operation of the motor consists in moving only one control handle from the start position to the run position. This handle has contacts interlocked with the primary magnetic switch that closes on the first step; the remaining steps cut out the resistance in the secondary circuit, bringing the motor up to speed.

This motor has power-factor corrective capacity, and is installed primarily for the purpose of raising the power factor of industrial plants. The motor may be used on any constant-speed drive, provided operating conditions are such that the application is justified. It is always best to use these motors where the service is continuous for long periods, such as air compressors, lineshafts, blowers and other drives of similar nature. Since the motor has slip-ring starting characteristics due to the resistance in the secondary circuit at start, it can be used on loads requiring a high torque to start. Furthermore, it is often possible to use smaller motors of this type than the regular squirrel-cage induction motor, as the torque of the latter type is very low compared with the slip-ring type, which is practically identical with the Fynn-Weichsel.

JAMES B. HOLSTON.

Commercial Engineer,
Wagner Electric Corporation,
Chicago, Ill.

IN ANSWER to the question by H. T., the Fynn-Weichsel motor operates as a slip-ring induction motor at synchronous speed. It starts as a slip-ring induction motor, and has much better starting characteristics than the usual squirrel-cage motor; that is, it will develop 150 per cent torque with a starting current of 150 to 200 per cent of full-load current. After the motor attains synchronous speed, which it will do easily with a 150 per cent load, it becomes an over-excited synchronous induction motor, the excitation varying with the load. With appropriate windings, the motor can be made to operate at unity power factor or with a definite leading current to compensate for the lagging current taken by other motors on the same line.

As a synchronous induction motor, the Fynn-Weichsel motor will carry 150 per cent load without falling out of step. Above this value it takes on induction motor characteristics and continues to run as a slip-ring motor to the breakdown point of approximately 300 per cent load before it stops.

This motor combines the favorable and desirable characteristics of both slip-ring induction and synchronous motors, and yet possesses none of their most objectionable features.

Loading this motor beyond the limits

of the synchronous speed operation simply establishes slip sufficient to carry the load as an induction motor. There is always a synchronizing tendency that reduces the slip and when the load decreases to a point below 150 per cent of full load, it pulls the rotor back into synchronism. The value of this characteristic is very important, as it enables the motor to carry temporary excess overloads in the same way that the squirrel-cage or slip-ring induction motors will carry overloads, thereby making the motor just as stable and practical in its operation as present types of induction motors. However, the chief value of this motor lies in the fact that it can be used for power factor correction.

The Fynn-Weichsel motor is connected to an a.c. controller in practically the same way as any slip-ring motor.

Electrical Engineer, WM. MCGUIRE.
Carbondale Machine Co.,
Carbondale, Pa.

IN REPLY to H. T., the rotor of a Fynn-Weichsel motor is provided with a commutator and slip rings. There are two windings on the rotor: one is a direct-current winding, which is connected to the commutator, and the other is a regular three-phase winding connected to the slip rings, which are connected to the line.

The stator also carries two windings. One is the main direct-current field winding; the other is an auxiliary winding, placed 90 electrical deg. apart. The special control equipment that is necessary, which includes a faceplate starter having two resistors, one for each of the stator windings, usually comes with the motor.

In starting a Fynn-Weichsel motor, the line switch is closed and the handle of the faceplate starter moved from the off to the running position, which operation should take about 15 sec. During this process a resistance is connected in the main winding and also in the auxiliary winding. This gives the motor a starting performance similar to that of a slip-ring induction motor. The resistance is gradually cut out until finally the running position is reached. when the auxiliary resistance is cut out altogether and carries no current, and the resistance is also cut out of the main winding. The main field winding receives its direct current from the commutated rotor circuit.

Fynn-Weichsel motors are ordinarily connected for clockwise rotation, but should it be necessary to change the direction of rotation, change two wires on the slip rings and move the rocker arm from right to left or in the reverse direction, as the case may be. The direction of rotation of the motor should correspond with the direction indicated on the rocker arm.

The starting characteristics of a Fynn-Weichsel motor are similar to those of a slip-ring induction motor. In addition a Fynn-Weichsel motor will draw only 150 to 200 per cent of its full-load current when the starting torque of this motor is 150 per cent of the full-load torque. Now, immediately after the motor comes up to synchronous speed, it becomes a self-excited, synchronous-induction motor. At normal load the motor operates at leading power factor, thereby compensating to a certain extent for the lagging current taken by other induction motors on the line. This motor operates as a synchronous induction motor up to 150 per cent of full-load torque; on heavier loads it operates as an induction motor. W. R. WOLFE.

Vancouver, B. C.

IN ANSWER to the question by H. T. the Fynn-Weichsel motor is a synchronous-induction motor. It operates as a synchronous motor from the time it reaches synchronous speed and can correct the power factor of other induction motors on the line until a heavy overload causes its speed to be reduced. Then it assumes the speed, power factor and losses of an induction motor.

The main operating current enters the rotor through brushes and slip rings. Besides the rotor winding, the shaft carries a small direct-current winding and the necessary commutator and brush rigging for current collection.

The stator windings are in two parts, being displaced 90 electrical deg. from each other. One of them is supplied with the direct current generated by the small winding on the rotor and the other is complete it itself, except during the starting period when both stator windings have variable resistances cut in series with them by the starting controller.

In brief, the Fynn-Weichsel motor is essentially an induction motor up to the point where the direct current acting on one stator winding helps to pull the motor into synchronism with the operating current; after this its characteristics are those of a synchronous motor.

In operation, the power factor is leading until the torque demand on the motor reaches approximately 150 per cent of full-load torque. If the torque load is increased beyond this point, the motor drops out of synchronism and assumes induction motor characteristics with such good overload capacity that it will not pull out or stall until approximately 300 per cent of full-load torque is reached. On the other hand, if the torque does not reach the pull-out stage but decreases instead, the motor begins to approach synchronism again and will actually attain it if the torque drops to 150 per cent of its full-load rating.

If there are other motors in the installation, the Fynn-Weichsel motor will ordinarily be able to supply leading current for correcting the power factor of the plant.

These motors are available in sizes from five to several hundred horsepower and are featured in three-phase types, but there does not seem to be any reason to doubt that two-phase motors of this type could be just as easily manufactured. In general appearance this motor resembles a wound-rotor induction motor and has an equally good starting torque. For starting purposes the controller is equally simple.

This motor costs more than either a squirrel-cage or wound-rotor motor of the same speed and horsepower; hence the only reason for using it will be on account of its ability to correct power factor and no doubt there are many plants where it is the answer to the power factor problem. On the other hand, as it is newer on the market than either a synchronous motor or a static condenser, time will be well spent in making a thorough study of these three methods of correcting power factor before any decision is made.

Vancouver, B. C. L. E. DUNHAM.

REPLYING to H. T.'s question, the Fynn-Weichsel motor has its primary winding on the rotor and receives its power current through slip rings on the rotor shaft. The excitation of the motor is supplied from an auxiliary winding through a commutator on the same shaft, and standard type slip-ring starting equipment is employed.

The motor starts with the characteristics of a slip-ring induction motor and operates as a synchronous motor under normal load conditions, but automatically becomes an induction motor if pulled out of synchronism by an excessive overload. When the overload has been sufficiently reduced, the motor automatically pulls back into step as a synchronous motor.

The power factor of the motor, depending, of course, upon the amount of excitation, is unity or leading at full load. These motors have a high starting, accelerating, and pull-in torque, and also ability to carry heavy overloads. PERCY LAMOTHE.

Smooth Rock Falls, Ont.

WITH reference to the inquiry by H. T., Fynn-Weichsel motors are designed for general use and embody the characteristics of two types of ordinary, well-known motors that have been on the market for a number of years: the standard slip-ring induction motor and the synchronous motor.

Compared with the induction slip-ring motor, the Fynn-Weichsel motor has very high starting torque, is power factor corrective, and is able to stand heavy overloads or highly fluctuating loads without an appreciable change in speed. As compared with the ordinary synchronous motor, it has a much higher starting torque, does not require a separate source of direct current for field excitation, and is not so likely to pull out of step when a heavy, momentary overload comes on.

The construction of these motors differs widely from that of the induction or synchronous motor. The rotor is provided with a set of slip rings and a commutator and has two separate windings in the slots, one above the other. In the bottom of the slots is the d.c. winding that is connected to the commutator. The standard polyphase winding, connected to the slip rings, is in the top of the slots.

The rotor of a Fynn-Weichsel motor might be compared to an armature from a d.c. generator that is so con-

structed that the commutator is at one end of the shaft and a set of rings, which are connected for compensating purposes to the armature, placed at the other end of the shaft. The stator resembles an ordinary induction motor stator except that it has two separate windings. These two windings are known as the main d.c. field winding and the auxiliary winding. These windings are displaced 90 electrical deg. from each other.

Under normal running conditions the d.c. field winding in the stator is connected in series with the brushes on either side of the commutator. The stator auxiliary winding is short circuited and the power source is connected to the slip rings. When starting, resistance is in circuit with both windings of the stator, and as soon as the motor comes up to speed, throwing the starter from the starting to the running position completes the connections, as outlined above. Under these conditions the motor has the main field winding automatically supplied with direct current from the rotor through the commutator.

A few words might be said in regard to changing the rotation of these motors. On ordinary induction motors it is, of course, only necessary to reverse two of the motor leads, but with a Fynn-Weichsel motor it is also necessary to shift the rocker arm carrying the commutator brushes. These rocker arms are all carefully marked for their two positions, giving clockwise and counterclockwise rotation of the rotor. The reason for changing the rocker arm is to cause the machine to generate direct current after its rotation is changed.

The question of starting equipment is not one to cause much difficulty even though it requires a little extra equipment. H. T. might use ordinary starting compensators by adding the two resistances and a means of cutting out these resistors when the motor is running full speed or the starter is in the running position. The standard starters for these motors are no more complicated than a regular compensator or the starting equipment for a slip-ring induction motor, and they are much more simple than the starting equipment for a synchronous motor in spite of the fact that such starters are now made entirely automatic; simply pushing a button starts or stops them when required.

There are many applications for Fynn-Weichsel motors and the following is a general idea of applications rather than a long discussion of unimportant details. They should be used where constant speed is required or on jobs requiring a high starting torque. Then, in cases where an induction motor would be running idle a large part of the time, these motors may be applied to secure the advantage of their power factor corrective ability. In locating these motors in damp or dusty places or where they will be subjected to acid fumes, much care must be taken to see that they are properly protected. It is best with this type of a motor to apply it where it will be clean, dry and away from dangerous fumes.

These motors are generally far too expensive to be applied for power factor correction alone, but when used around an industrial plant with other motors they will boost the power factor enough to make a material saving, because the nearer a plant runs at unity power factor the less the copper losses in transformer and distribution lines will be. The Wagner Electric Corporation manufactures this motor, and will, no doubt, be glad to furnish any other information desired.

Donnacona, Que. LEE F. DANN.

Best Kind of Insulation for Semi-Closed Slot Motors

I shall appreciate it very much if readers will tell me whether it is better practice to use varnished cambric between the coils in a semi-closed slot motor, thereby insulating each coil from its neighbor, or to tape each coil separately and then use insulation only between phases.
Rome, Ga. M. S. C.

IN REPLY to the question by M. S. C., the choice of insulation is largely a matter of opinion, governed by operating conditions. For motors operating in damp places and in places where they are subjected to acid fumes, I have found that the following method gives excellent results:

We use Armco fiber paper for slot liners in all of our motors, and in the semi-closed-slot motors one thickness of paper is used in the slot for each coil; that is, a liner is placed in the bottom of the slot and then a paper liner that comes up to the top edge of the slot. When inserting the second coil in the slot another liner of paper is put in, which insulates the coils from each other.

This Armco paper is very tough. It will withstand much binding before it breaks, and will not tear easily at the end of the slots where the coils pull sidewise against the paper. This paper can be obtained in sheets of various sizes and various thicknesses. For all our work on 550-volt motors, we use 10- and 15-mil paper. In the semi-closed-slot motors we use two thicknesses of the 10-mil size, and in open slot motors one thickness of 15-mil paper is used.

We believe that the proper treatment of the coils before they are installed in the motors really has more to do with the operating life of the motor than the slot liners. On page 95 of the February, 1927, issue of INDUSTRIAL ENGINEER, there is an article on the preparation of coils for semi-closed-slot motors. The results we have obtained with coils treated in the manner described in that article have been incomparable. I have actually seen some of our motors started up with water dripping from every part. This happens regularly in two or three very damp places around the mill and up until the time we rewound semi-closed-slot motors in the manner described in that article, we experienced trouble from short-circuited and grounded coils. Personally, I believe any paper that is tough, non-porous and of average texture and thickness suitable for coil slots. L. F. D.

REPLYING to the question by M. S. C., the usual practice in contract shops is to tape the knuckles of coils about 1 in. each way with half-lapped cotton tape, this tape being about 0.007 in. thick and 0.75 in. wide. The coils are then wound without dipping, phase insulation being inserted as the coils are wound. Naturally many different shops have their individual ideas concerning the amount of insulation required. Some use one thickness of 0.01-in. varnished cambric between phases for 600 volts or below; others use two thicknesses, and still others, three. Only a few shops, with whose methods I am personally acquainted, use phase coils. These phase coils are usually placed in open-slot motors, and in this case it is a good plan to use canvas strip doubled between the top and bottom halves of coils where they project out of the slot.

On 2,300-volt equipment closed-slot coils are usually taped up to the slot, even if this has to be done after the coils are placed in the slots. This type of motor is not very popular and I am sure that the open slot for this voltage will entirely replace it, as the more modern motors for this voltage seldom use closed or semi-closed slots.

Several manufacturers are tying their coils, especially on the smaller sizes, and inserting empire cloth or varnished cambric between the coils. Personally, I believe that this gives a safer winding for low voltage than does taping at the knuckle and inserting phase insulation. If this method is used, I believe it would be a good plan to use double the amount of insulation between phases. Even though taping is discontinued, the sleeves should be put on the coil leads just the same, in which case spaghetti tubing could be used on the jumpers, thus saving time in connecting up the motors.

If the jumpers are taped, two layers of half-lapped cotton tape, or one layer of cotton and one of varnish cambric, can be used for voltages below 600. On 2,300-volt motors some shops prefer to use two layers of varnished cambric and one of cotton; others use one layer each. On 220-volt motors, sleeving dipped in air-drying varnish and then dried can be used instead of tape.

Contract shops almost always put in as much insulation in the slot as the space allows. Seldom are less than two 0.01-in. fishpapers used with 0.010-in. varnished cloth sandwiched in between. In winding semi-closed-slot motors, 0.015-in. or thicker paper is used, if there is plenty of room next to the coil. The stiffness of the paper will tend to hold it close to the slot wall and will prevent the paper from crimping at the corners when the coil is inserted. This is an advantage in stators with narrow slots.

It is a good plan to use cotton-covered, enameled wire, if space is limited. Al-

ways use either double-cotton or cotton and enameled wire in closed-slot motors; single-cotton-covered wire is seldom sufficient.

Cotton tape will stand about 100 volts per mil; double cotton covered about 150 volts; mica, 800 volts; varnished cloth, 750 volts; and fishpaper, 250 volts. These materials have a capacity increase of 100 per cent when impregnated and baked with a reliable varnish.

The factor for insulation that is generally used is 70 volts per mil for an a.c. machine and is calculated for the terminal voltage of the machine. However, for a 220-volt machine this would be only about 3 mils, which is not mechanically strong enough to allow for the insertion of coils and resultant handling. So, for mechanical reasons this rule cannot be applied to low-voltage machines and various papers are used in connection with Micanite and empire cloth. These papers constitute fair insulation when dry, but if moisture is present their insulating value is very low; hence the necessity for baking completed windings before dipping. This baking drives out the moisture and also the air, which allows the varnish to penetrate more readily.

GRADY H. EMERSON.
Birmingham, Ala.

ANSWERING M. S. C.'s question, at our plant after the coils are wound into the form of a loop, they are heated to a moderate temperature and dipped in a very thin solution of insulating varnish. We allow the coils to soak in the varnish, while still warm, until completely filled or saturated. When all signs of air bubbles have disappeared, the coils are withdrawn from the varnish container and hung up to drain off the excess varnish. When the draining-off process is finished, the coils are removed to a warm place and left hanging up until they have thoroughly air dried. The time required to dry the coils properly is about 24 hr. The coils are now ready to be spread. After this is done the ends of the loop are then wound with linen tape for a short distance, nearly up to where they rest in the slots.

Before placing the coils in the slots, the turns are given a coating of parowax. This gives the coils a nice, smooth surface and makes it much easier to pass the turns through the openings in the slots. It is a well-known fact that an application of parowax is beneficial on all winding jobs and most winders make use of it extensively.

I would recommend the following for slot insulation for 220-volt machines when a heavy thickness of fishpaper is used to cover the whole slot: Use a layer of varnished cambric, letting it protrude, say, about 1½ in. above the slot so as to act as a guide for the turns of the coil. After the bottom layer of the coil is in place, cut off the varnished cambric even with the top of the slot, ramming the ends down in the slot so as to envelop the coils. If there is enough space, you may add a strip of fiber between the bottom and top layers of the coils; it is a very good plan to also put a strip of fiber in the very bottom of the slot.

For the top layer, lay another piece of varnished cambric in the slots the same as for the bottom layer and then proceed as with the bottom layer, finishing the slot by driving in the retaining fiber wedge. When all the coils are assembled in place, heat the whole motor to a moderate temperature. Dip the whole motor in warm baking varnish, allowing it to soak well until saturated. Then allow it to drip for about one hour before putting it in the baking oven.

H. J. ACHEE.
Superintendent,
City Water & Light Dept.,
Woodward, Okla.

IN ANSWER to the question by M. S. C., the first method which I will describe for insulating semi-closed-slot motors has proved very satisfactory at our plant, some of the motors being 20 years old. After trying many methods of insulating motors, I have found it best to mold 0.010-in. No. 1 Micanite plate for slot insulation, winding the coils in groups to eliminate soldered connections and insulating each coil with 0.007-in. Armco paper and 0.015-in. oiled cambric between phases. Then dip the motor, after heating it to 80 or 90 deg. C., in General Electric No. 460 baking varnish. Two dippings in this varnish should be made, thoroughly baking after each dip.

Then I apply No. 8 Bakelite compound as a paste to the whole winding. This gives a thoroughly oil- and moisture-proof insulation. Some of these motors have run under water that was not very pure with no apparent ill effects. The Bakelite, however, requires some skill in applying and baking. For instance, it is necessary to moisten the hands in kerosene to keep the Bakelite from sticking to them, as there is no solvent that I have found that will remove it. Although it can be applied with a paddle or putty knife, it is best to apply it with the hands, so as to force it thoroughly into all the crevices in the winding.

However, if you do not care to use Bakelite or some other sealing compound, of which there are many on the market, taping and then baking each coil is the best method, although I have found it cheaper to use the above procedure. For instance, I have stripped, wound, baked, and had running in 21 hr. a 20-hp., G.E., 1,200-r.p.m., three-phase, 60-cycle, 440-volt, 50-deg. motor. My efforts resulted in a first-class job both in looks and durability. Winding the motor was a small job, taking in all about 6 hr. for two men, this time including that required for making the connections. Consequently, I have now standardized on mica insulation for all semi-closed-slot motors and wound rotors, the rotors being a complete mica job, as no other insulation is used.

Some of these motors have been running for three years, direct-connected, and I have not had a failure except in one case where we baked the Bakelite too fast. This material must be held at 60 to 65 deg. C., a slow heat being necessary to prevent blistering. Many of our motors operate months at a time, without even stopping, at an operating temperature of 80 to 90 deg. C., while before using the present method we rewound on the average one motor a month, as there are fourteen motors of this size and type in our plant.

For bearings, we use Stewart bronze, which has been considerably more satisfactory than babbitt. During the past three years our monthly motor inspection report shows that our bearings have worn less than 0.002 in.

R. I. FROST.
Chief Electrician,
National Cement Co.,
Ragland, Ala.

IN ANSWER to the question by M. S. C., I would strongly advise taping each coil throughout with Linotape; then over this wind a layer of cotton tape. After this is done there is no necessity for additional insulation between the phases, as there will be at least two thicknesses of Linotape between the coils. Taping the coils throughout with Linotape also makes them practically moisture-proof, lessening the chance of internal shorts in coils caused by dampness or fumes.

I have found that insulation placed between phases often becomes loosened and dislodged by vibration, thus leaving only cotton tape between the coils; in such cases a breakdown in the insulation usually results.

The cost of insulating coils in this way is very little higher than other methods. Personally, I have used this method for over six years on motors that are operating under very severe conditions and have had very little trouble.

C. McCOLLUM.
Chief Electrician,
Gunns, Ltd.,
West Toronto, Canada.

IN ANSWER to M. S. C., I believe he will find the standard practice used in our shop to be a very efficient method of insulating the coils in semi-closed slots. We take 25- or 30-mil Armco paper and cut separators. After one coil is inserted in the slot, the paper is cut as wide as the slot on top of the first coil, and then it is placed between the two coils.

The coils are taped on the ends only, thereby allowing the winder to separate the ends or turns to be put in the slots. If it is desired to tape the coils fully, this will have to be done after the coil has been inserted, but it takes more time than our method.

To get the correct width of the separator, cut a piece of Armco paper, 25 mils in thickness, to the shape of the wedge. Insert the narrow end in the slot from one end, and mark it just where it touches both sides. The separator should be neither too narrow nor too wide, for if too wide it will fold on the sides and if too narrow it has a tendency to turn. M. S. C. could then use varnished cambric between the phases.

J. M. PETERSON.
Troy, N. Y.

Electrical Service

AROUND THE WORKS

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Hoist Trouble Encountered While Repairing Ammonia Purifier

FOLLOWING in line with our perpetual campaign of Safety First, the writer eliminated a hazard that could have easily caused a serious accident, both to workmen and equipment. On the evening that the armature of a hoist motor, which had burned out, was being installed, trouble was encountered in the form of a leak up near the top of the ammonia purifier, which is located in a six-story building and reaches from the bottom to the top floor.

In order to locate the trouble it was necessary to remove the cover and top ring of the purifier and lower them to the ground floor. This work was done by means of a monorail electric hoist located overhead, and a set of rails for moving the hoist over the different machines or stills.

The hoist is manipulated by hand chains at one end of the bridge or monorail, and the motor, which is geared to a drum having enough cable to reach the ground floor, is controlled by a standard G-2 faceplate type controller, mounted directly on the side of the hoist. The controller is actuated by hand ropes with suitable wood handles connected to each end of the controller arm and within reach of the operator.

After the cover of the purifier had been removed and lowered to the ground floor, the hook was hoisted again to the top of the machine to remove the top ring. Then the operator left the controller and started maneuvering the hoist over the still. At this time the operator had unknowingly opened the controller with the result, to my amazement, that the block and hook, which were but 1 or 2 ft. from the top limit of their travel, suddenly moved upward at full speed directly over the heads of the workmen. Realizing there was no limit switch on the hoist, and that the line switch was on the floor below, I climbed from my position on top of the machine next to the one being repaired, which is three rings higher, to a position just over the side, where I discovered the rope on the hoist side of the controller arm was fouled between a pipe flange and a projecting bolt. It was but the work of a moment to kick the rope free, but not soon enough to keep the block from jamming and badly straining the cables.

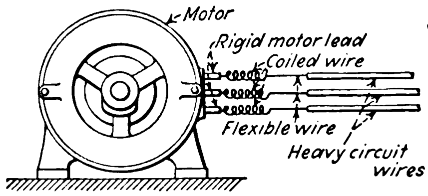
Very fortunately, however, no one was injured. Needless to say, I immediately started to plan the removal of the controller from the hoist, and after considering several plans, decided on mounting it on the wall overhead and in front of the shaft. I also brought the line switch up and mounted it at a point about 4 ft. above the floor where the operator stands, and beneath and just a little to one side of the controller.

A. L. BINGHAM.

Chief Electrician,
The Ironton By-Product Coke Co.,
Ironton, O.

Rigid Leads Cause Three-Phase Motor to Run Single Phase

ONE job, which I had occasion to service, was located out in the country. The motor that was giving trouble was arranged so that it would swing while driving a circular saw. It had evidently been running single phase, for they told me that they used to pull the belt to start it, but when at last this method failed, they, of course, found it necessary to call in a service man.



This shows how a motor may be connected to safeguard against the breaking of the lead wires within the motor.

When I opened the motor I found it full of dirt and the leads were all broken loose from the terminals by the constant straining back and forth with rigid connections. Whoever wired up the job did not use flexible cable to connect the motor terminals to the line. As these leads were rigid, the terminal wires inside the motor gave out first, being the weakest point in the line.

The method of repair that I adopted was to supply the motor with flexible leads so that there would be no more straining on the line, especially inside the motor, in the future. I connected one end of a coiled wire to the motor terminals within the machine and braced it securely to the frame so that no motion of the conductor would occur within the motor. After connecting the flexible wires between the coil wires and the heavy circuit wires, the job was completed as indicated in the accompanying illustration. Although this job was supposed to be a temporary one, it was rendering satisfactory service the last I heard of it.

E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Isolated Substation Improves Operating Conditions in Coal Mine

IN THE coal-mining industry, the distance from the pit mouth back to the working face may be several miles, and for every ton of coal mined this working face advances farther from the mine mouth. The substation that supplies power for work underground is usually located at either the mine opening or ventilating shaft, which is a considerable distance from the load center.

The effect of the long lines that must be run to carry d.c. power to the workmen and machines underground is quite often shown in the decreased production which results from insufficient voltage at the working face. Motors working at reduced voltage may have frequent armature burn-outs, even though they may be operating at far less than their rated capacity. At the present time, when mining costs must be held at a minimum, the question of better voltage regulation is a vital one to the operating department.

We found that voltage regulation was poor at our mine shortly after production started, the entire output of which is consumed at our steel mill power house.

We expected to transmit d.c. power from the mill substation, a distance ot about 1¼ miles, at 275 volts, but we found it would be impossible to maintain proper voltage later on because of the rather rapid advancement of the working face.

Accordingly, we built a 2,300-volt, three-phase, 60-cycle line from the mill power plant, a distance of about 2 miles, and located a substation on the surface at the approximate center of the future workings, where we installed a Ridgway motor-generator set with General Electric automatic-reclosing d.c. circuit breakers. The d.c. cables were run through a bore hole to the mine workings underground.

As this automatic substation is isolated and unattended, it was quite important that it should be protected against abnormal conditions; so protection was provided against overloads in the d.c. line and in the a.c. circuit. The synchronous motor starting equipment is manually operated and provided with overload and undervoltage protection. Bearing relays are installed on the motor-generator set, so that in case of a hot bearing the set is shut down and if an overload opens the synchronous-motor circuit, an attendant must go to the station to determine the trouble and restart the set.

Some of the advantages to be had from an installation of this kind are good voltage at the working face, no labor cost for the usual substation attendant, and no large expenditure for complicated automatic control equipment or heavy copper feeders for long distance d.c. power transmission.

J. S. MURRAY.
Chief Electrician,
Follansbee Bros. Co.,
Toronto, Ohio.

Method of Drying Lumber With Electric Heat

BY THE use of electric heat for drying its lumber, the General Electric Co., Schenectady, N. Y., claims that the Chicago Lumber Co. of Oakland, California, has found it can dry its lumber in two days time, without damaging the wood, and with low operating costs.

This company has made two installations of electric lumber drying equipment in its plant. The drying box used has dimensions approximating 10 ft. wide x 7 ft. high x 21 ft. long. The compartment is constructed of ship-lap backed by moisture-proof paper, and insulated with packed shavings. The lumber to be dried is principally short lengths used after drying to make up window and door casings.

The moisture removed is calculated to be equivalent to 5 per cent of the weight of the dry lumber, and this drying is accomplished within 48 hr. without end-checking or other damage to the lumber. It was estimated before installation that the drying would require 100 kw.-hr. per 1,000 board ft. of lumber, but actual operation has shown a much better economy. The cost of power is 1.15c. per kw.-hr., comparing favorably with the cost of oil at $1.25 per bbl. of 42 gal.

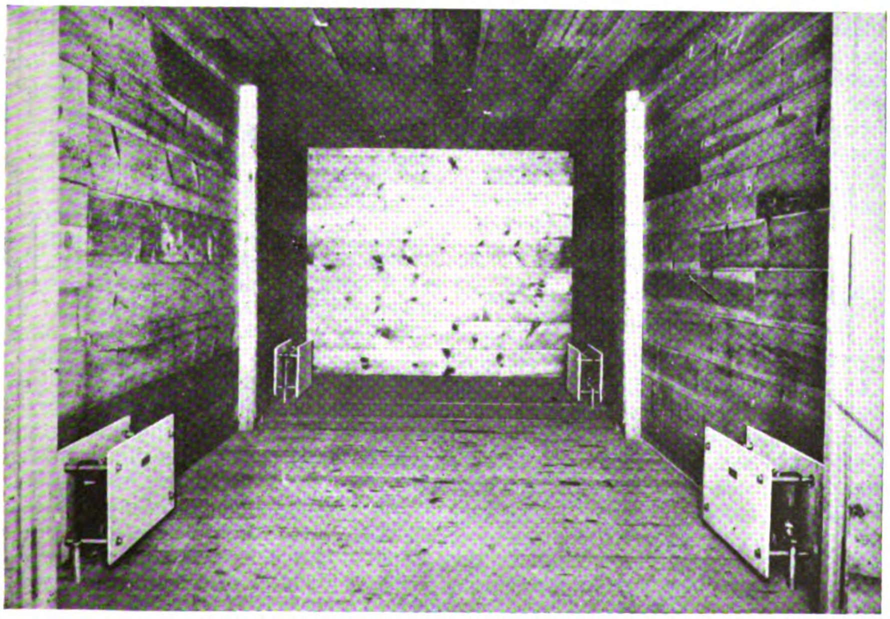
The electrical equipment consists of heating elements with a total connected load of 15 kw., four General Electric form G oven heaters being used. The temperature is automatically controlled at 90 deg. F. at the beginning of the drying cycle and at 120 deg. F. near the end of the period by means of an automatic control panel and a Bristol temperature control.

The cold air is drawn in by natural draft through four openings in the floor of the drying compartment, and a heater is placed over each opening. The hot air rises to the ceiling and there it deposits part of its heat and is cooled off. Then it drops to the floor level before it can pass out through the exhaust air ducts, one on each side of the drying box, which extend from the floor up through the roof. In this manner the air is caused to pass over and through the lumber and pick up moisture on the surface of the lumber. This method is employed so that the efficiency of the oven will be increased.

The temperature controller has a sensitive bulb 25 ft. long which is spread out over the ceiling of the compartment and thus controls the average temperature over the whole of the drying box. The lumber is run into the drying compartment on trucks and is so loaded as to give ample space around each piece to allow free air circulation.

This company has also installed electric heating units in its glue room where window and door sash parts are glued together. In this room, which is 20 ft. x 60 ft. x 12 ft., it is necessary to keep the air heated so that the glue may be thoroughly dried by the time the sash has passed from one end of the gluing machine to the other.

This shows the respective positions of the heating elements and vent ducts.



Disintegration of Studs Due to Defective Slate Panel

TROUBLE with one of our switchboard panels, which was located in a rather damp place, proved to be very elusive until it was discovered that two studs had broken off in the panel. These studs were fastened directly to the panel without any insulation.

After dismantling the connections on the board, it was found that the studs on one side of the d.c. line were surrounded by a white deposit and were being slowly eaten away, while the studs on the other side of the line had dark patches on them.

After a thorough investigation, it was found that the slate panel contained traces of some chemical impurity, and these impurities in conjunction with the moisture formed a high-resistance path between the positive and negative studs.

To remedy this trouble, all studs and connections carrying current and passing through the panel were insulated with mica tubes. Only thin sheets of mica were used, as it was only necessary to prevent the copper and brass connections from touching the slate.

W. E. WARNER.
Shefford, Bedfordshire, England.

Simple Mistakes That Resulted in Failure

I HAVE seen so many mistakes made that it seems hardly possible to mention an original one, although several interesting examples were seen during a recent trip. One mistake occurred in a woodworking plant, where so much care is exercised in fire prevention. Sparks were seen coming out of the cabinet of a potential starter. Upon investigation, it was found that the oil level was low, but instead of using switch oil, ordinary light lubricating oil had been substituted, which was not suitable.

Another job that gained my particular respect was in a large oil refinery that faced a serious predicament owing to the expected failure of one of the main pumps which composed just half of the pumping system. The motor driving this pump developed a heavy knock, causing it to vibrate. Two and one-half days had been spent on this equipment trying to remedy the trouble, for it was essential to keep the unit in service. When I arrived, the motor was still in service, but vibrating as badly as any 200-hp. d.c. motor could and still remain on the foundations. The trouble was readily apparent when I placed my hand on the field coils, finding all except one extremely warm.

The trouble was diagnosed as a shorted field coil, which was evidently correct, for it ran properly afterward.

E.J.M.

MECHANICAL MAINTENANCE OF Power Drives

Anti-Friction and Sleeve-Type Bearings on Motors

AT THE recent convention of the Association of Iron and Steel Electrical Engineers in Pittsburgh, Pa., Mr. F. W. Cramer, Ass't. Electrical Supt., Bethlehem Steel Co., Johnstown, Pa., presented a paper "An Analysis of the Motor Bearing Problem," which was abstracted on pages 323 and 324 of the July issue of INDUSTRIAL ENGINEER. Some of the discussion on Mr. Cramer's paper was also printed on page 329 of the July issue. The interest with which this paper has been received indicates that Mr. Cramer has made a very valuable contribution to industry on the motor bearing problem. It is very helpful in that it shows the advantages and the disadvantages of both the anti-friction and the old, reliable, sleeve-type bearings. It is only by frank discussions, such as this paper brings out, that we can form opinions on the merits of the two classes of bearings for electric motors.

My experience with motor bearings would lead me to concur in the statements made by Mr. Cramer. The real reason for suggesting the use of anti-friction bearings on mill motors was, in my opinion, the fact that records show that a very large percentage of motor failures is caused by oil leaking out of the bearings and onto the motor winding. This oil, together with the dirt present in steel mills, especially, has caused excessive winding failures. This condition, however, was no fault of the sleeve bearing proper, but was due to the inadequate design of the bearing housing which permitted the lubricant to escape and the gritty dirt to get in, thus shortening the life of the bearing.

It is my opinion that it makes very little difference whether a bearing is babbitted, or consists of steel rollers or balls. If the housing is properly designed, with particular reference to holding the lubricant in and the dirt out, an exceptionally good bearing will result.

We have experimented with both types of bearings during the past five years. We were probably one of the first in the field to try out the so-called sealed sleeve bearings on general-purpose motors at the Toronto plant, in September, 1923. This original set of bearings is still in service. In fact, it ran two years with the original oil. The bearings were taken apart at the end of that time for inspection and found to be in perfect condition. Needless to say, the motor windings were bone dry and the bearings perfectly clean.

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

We have made about 100 installations of this class of bearings since that time, and at a very small percentage of the original motor cost. The results in every case have been entirely satisfactory. Had we equipped these motors with anti-friction bearings, it would have meant new motor shafts, and scrapping our stock of spare bearings. As it was, we were able to use the latter by making a slight change in the dowel pin holes.

Our experience with anti-friction bearings has been with installations on motors, where no efforts were made by the manufacturers to improve the original sleeve bearing, thus justifying the expense of machining the housings and installing anti-friction bearings. Some of these installations have been successful, whereas others were absolute failures. In fact, I know of one installation where sealed sleeve bearings replaced roller bearings entirely.

In conclusion, so far as I know there are no outstanding examples of where the anti-friction bearings are superior to sleeve bearings, when both are comparable in workmanship and materials; certainly the sleeve bearings are cheaper to install and maintain. However, I hold no brief for the old-style sleeve bearing. I believe that when contemplating the purchase of new motors the advantages offered by both ball bearings and *modern* sleeve bearings should be carefully considered and a choice made that is based on the suitability of the type chosen for the particular application.

J. S. MURRAY.

Chief Electrician,
Follansbee Bros. Co.,
Toronto, Ohio.

Comments on "Application of Gears and Speed Reducers on Motor Drives"

THE article entitled "Application of Gears and Speed Reducers on Motor Drives," by Gordon Fox, which appeared in the April issue of INDUSTRIAL ENGINEER, contains several statements concerning non-metallic pinions which I feel are open to criticism and correction.

In the paragraph beginning at the center of page 163, Mr. Fox refers to the various types of pinion material and then states: "The two latter types (rawhide or cloth) have end plates of brass." In so far as rawhide is concerned, it is true that end plates are used, although other materials are more frequently used than brass. In the case of the "cloth" gear, the use of side plates is the exception rather than the rule. Side plates are used on this type of material only when heavy loads are being driven and added support for the key slot is thought to be essential. In such cases the side plates extend only to a point slightly below the root of the tooth.

It might be well to state before proceeding further that the word "cloth" in this article covers two distinct types of non-metallic gear materials. One type of gear, known commercially as Fabroil, does use shrouds and these shrouds extend to the top of the teeth. The other type of "cloth" gear is a molded product composed of layers of cloth bonded or molded together by a resin compound, such as Bakelite. There are several makes of this type of "cloth" material on the market, sold under such trade names as Micarta, Textolite, Contex, Celleron, Formica, Fabroc, and others. It is of this latter molded type of gear that I write.

In the statement that "brass pinions are particularly adapted to extreme conditions of heat and moisture, which prohibit the use of a non-metallic pinion," we feel that Mr. Fox has overlooked one of the important features of the molded type of pinion, for we have found it to be an excellent article for just such uses. [Manufacturers of such gears state that the molded material is not affected by moisture, cold or temperatures up to about 200 to 250 deg. F.—EDITORS.] Molded gears are also used in applications where a weak acid solution is present, and in plating and similar types of baths which would have a decidedly disastrous effect on any type of metal pinion.

The statement that "the American Gear Manufacturers' Association recently adopted the recommendation that all non-metallic gears or pinions be estimated on a basis of 75 per cent of the rating of cast-iron gears of corresponding dimensions" is correct only from a purely mathematical viewpoint, inasmuch as the 6,000-lb. fiber-stress value at static load adopted for non-metallic materials is 75 per cent of the established 8,000-lb. for the same factor in cast iron.

As a matter of fact, I believe that is where the comparison ends, for we have found that the non-metallic pinion will outwear the cast-iron pinion in the vast

majority of cases and with speeds over 1,500 f.p.m. the inferiority of the cast-iron material becomes more conspicuous as the speeds increase.

On the question of speeds, the author, in the last paragraph on page 163, states in regard to rawhide, "a speed of about 2,000 f.p.m. is a fair average limit, but 2,500 to 3,000 f.p.m. may be used under favorable circumstances," and adds, in regard to cloth pinions, "the allowable surface speeds correspond to the values for rawhide."

Here, again, the author does not appear to recognize the fact that another of the features of the Micarta or molded type of cloth gear is its ability to give excellent service at speeds that would be prohobitive in many metals. Instead of 3,000 f.p.m. being the limit for satisfactory use we can cite instances where Micarta is being successfully used at three times that velocity.

Table I of his article mentions two grades of non-metallic material. The A.G.M.A. has established the factors 6,000 for non-metallic materials and 8,000 for cast iron without reference to grades. Furthermore, the A.G.M.A. at its recent meeting recommended as standard practice the use of a new formula as a substitute for the Barth formula in the stress factor of the Lewis formula for the calculation of tooth loads in non-metallic materials. This formula is $[150 \div (600 + V)] + 0.25$ and is replacing the age-worn $600 \div (600 + V)$.

By the use of the new formula the real value of the resiliency of Micarta and similar molded non-metallic materials is more correctly established in the tooth strengths, and this point, although generally recognized as being present, was never used in computations due to the lack of any specific data upon which the factor could be actually established.

Tests which have been conducted by Prof. Earle Buckingham at the Massachusetts Institute of Technology for about two years on the new Lewis testing machine have determined sufficient data at the present time to permit the establishment of the new formula. Although it is admitted that the new formula may be subject to a slight change after further tests have been made, it is also admitted to be far more accurate in its present condition in the proper determination of the tooth strength properties of non-metallic material than was obtained by use of the old formula of $600 \div (600 + V)$, which was established many years ago on cast-tooth, cast-iron gears running at a maximum pitch line velocity of 1,000 f.p.m.

Merely as a demonstration of the effect of the new formula on gear-tooth strength of non-metallic material, the following tooth loads were obtained by using $[125 \div (150 + V)] + 0.25$ with 6,000 lb. fiber stress for non-metallic material and $600 \div (600 + V)$ with 8,000 lb. fiber stress for cast-iron on an arbitrarily selected pinion of 3-in. diametric pitch, 15 teeth, and 2-in. face width running at the various speeds listed in the accompanying table.

It will be noted from this table that the non-metallic pinion will show approximately the same tooth strength at slightly over 2,000 r.p.m. (or at approximately 1,600 f.p.m. pitch line velocity) as the cast-iron pinion, and for all speeds above that the gain in strength over the cast-iron pinion is quite pronounced.

Speed R.P.M.	Tooth Strength in Horsepower Cast Iron	Non-Metallic
500	9.02	5.63
1,000	12.93	8.93
1,500	15.11	12.06
2,000	16.50	15.00
3,000	18.18	20.72
4,000	19.14	26.42

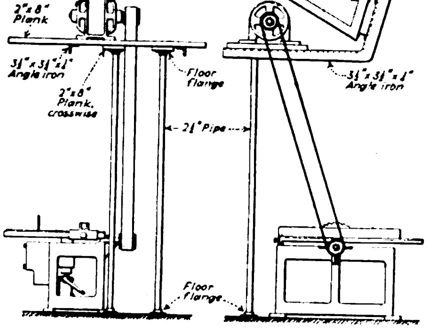
As the tests at the Massachusetts Institute of Technology continue, it will be determined just what additional factor can be placed in the formula to include the wearing properties of the material and when this factor has been determined it is believed that the superiority of non-metallic materials over many of the metals will be quite pronounced. Under certain conditions, the wear on the non-metallic material will be even less than that on hardened steel pinions, we believe.

Although it is appreciated that the article by Mr. Fox was primarily on the subject of speed reducers, and was very ably handled from that viewpoint, I thought it advisable, however, to call attention to certain present-day conditions existing in the non-metallic gearing field with particular attention to the developments that have been announced by the A.G.M.A. in May just after this article appeared. I hope that these comments are taken in the light of constructive criticisms, which is their sole object.

T. C. ROANTREE.
Non-Metallic Gear Application Engineer,
M. & P. Engineering Dept.,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

Supporting Motor Overhead in Saw-Tooth Construction

EVERY industrial operating man has been confronted with the problem of mounting motors, countershafts, or other equipment overhead where there was practically nothing to which they might be attached. Such was the problem confronted in a medium-sized mid-western factory and the solution may be of interest to others, who are called upon to meet similar difficulties.



This plant was of saw-tooth roof construction, of light design, and not intended for supporting loads from the ceiling. When the plant was built, it was expected that the few machines necessary would have individual motors, either built-in or mounted directly on the machine. The product handled was large in bulk but light in weight, so that it was not necessary to use overhead hoists or conveyors. The arrangement of each machine was carefully planned to give ample aisles and storage space for handling the product to and from the machines during the process.

The layout adopted, however, brought two of the woodworking machines under a sloping section of the ceiling, with nothing directly overhead on which to mount the motor. These two machines had been brought from the old plant and were of a type which could not easily be adapted to support the motor. Because of shavings and dust, it was not desired to place the motors on the floor, and a special mounting or platform built up from the floor would not only occupy needed floor space but would be in the way.

It was finally decided to make a special overhead platform for each motor, which was attached to the ceiling but supported from the floor. Accordingly, two pieces of 3½ x 3½ x ¼-in. angle irons about 6 ft. long were bent, as shown in the accompanying diagram, to conform to the slope of the roof and bolted to the steel structure in such a manner as to leave the two other ends extend out over the machine. Two 2 x 8-in. planks, about 3 ft. long, were bolted to these outer ends of the angle iron to form a platform for the motor.

Each platform was supported by two pieces of 2½-in. pipe attached to the floor. These pipes were threaded at each end and screwed into floor flanges, which were fastened by woodscrews to the floor and to short pieces of 2 x 8-in. planks mounted crosswise underneath the platform. One of these crosspieces and the pipe was placed directly under the motor and as near to the pulley end as possible, where it would support the most load.

This mounting, which placed the motor about 3 ft. away from the valley in the saw-tooth roof, was very substantial and practically free from vibration. The pipe supported the entire weight of the motor and platform, which in turn was tied to the ceiling from the side by the angle irons to prevent side motion. The planks in the platform were notched to let the belt pass through. The same method of construction could be used to support a countershaft, provided the side pull of the driving belt was not too great.

E. G. H.
Chicago, Ill.

Method used to mount motor in saw-tooth roof.
The motor is mounted on a platform built of planks attached to heavy angle irons which are bolted to the roof. This platform is held up by upright pipes which in turn are held in place by floor flanges screwed to the platform and the floor.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Specifications for Testing Insulating Varnishes

THE method of testing insulation varnish, which is described in this article, I have found very satisfactory, especially for manufacturers of electrical equipment whose laboratory apparatus is limited. As these tests should be comparative, the various brands of varnish on hand should be tested at the same time in the same oven, so as to be absolutely fair to the different brands, for the test temperature is largely the deciding factor.

It will be well to remember that the following specifications for testing insulation varnish are not only useful to check the grade of varnish ordinarily used, but to determine the quality of new brands of varnish.

(1) *Materials Covered*—These tests are intended for varnishes which are applied by brushing, dipping or spraying and are primarily for the purpose of providing electrical insulation.

(2) *The Working Viscosity*—To find the working viscosity, cut pieces of good bond paper about 4 in. x 20 in. x 0.0024 in., drawing an ink line across the paper every 2 in. starting from the top. Then immerse these prepared sheets to the top line in clean varnish free from air bubbles and at the specific gravity recommended by the manufacturer. Then withdraw evenly and rapidly, and allow it to drain thoroughly in a vertical position. Bake or air-dry the sample long enough to set the varnish, and then immerse again as previously directed. Then bake 12 hr. at 200 deg. F. Measure the thickness in mils at each of the inked lines or every 2 in. in case of black varnish. From this thickness subtract the thickness of the paper and divide by two. This result will give the working viscosity or slip of the varnish.

(3) *Time of Drying*—Specimens for this test shall be pieces of 0.0025-in. bond paper similar to that used in making working viscosity tests. The specimen should be dipped once in the varnish, withdrawn rapidly and allowed to drain in vertical position, and either air-dried or baked according to material to be tested. The baking temperature should be 200 deg. F. and the air-drying temperature 70-deg. F.

Examine the specimen every 30 min. to find the setting time or that at which, when pressed with your finger, a mark will be made which is not obliterated by further flow. (Baking varnish to be at baking temperature.)

The surface drying time is when the sample may be pressed tightly between thumb and finger on the 12-in. line and does not adhere.

The hard drying time is when a sheet may be doubled and the 2-in. and 12-in. marks pressed together without sticking.

The cracking time is when the sample can be doubled and drawn taut over a ⅛-in. mandrel.

This is very important, as the varnish that remains flexible the longest will, in most cases, be the best for armature winding, as it will stand up the longest under the heating and drying action of armature running under load.

(4) *Dielectric Strength Test*—Specimens for the dielectric strength test shall be prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or brass about 22 in. x 22 in. and about 0.05 in. thick, into the varnish. This varnish should be tested at the specific gravity recommended by its manufacturer.

Each specimen shall be dipped twice as specified in drying test, but allowing each coat to drain in the opposite direction in order to give a more uniform thickness of coating. The specimen should be dried after each dip in the opposite vertical position from which it was dipped. The time of drying shall be as indicated in the hard dry test.

The dielectric strength of the two films of varnish shall be determined by applying alternating potential to two brass disks, 1 sq.in. in area and with edges rounded to a radius of 0.25 in., which are placed opposite each other in contact with the two sides of the specimens and directly under a pressure of 1 lb. The potential should be applied at a low value and gradually raised at a rate of approximately 500 volts per sec., until puncture occurs. Ten such punctures are to be made at points every 2 in. along each specimen. In each test, the thickness of the films of varnish is to be determined as near to the point of puncture as practical.

The volts at puncture, the net thickness of insulation, and the volts per mil of net thickness, should be reported for each of the ten tests, together with the average maximum and minimum volts per mil. NOTE: It is very important that the circuit is not broken from the time the voltage is applied until puncture takes place. If the contact should be broken, the voltage should be run down to not more than 200 volts, and then start the puncture test all over again. For this reason a transformer with taps on it should not be used, but use an induction regulator in series with the primary of the testing transformer that should have a capacity of at least 5 kw. for voltages up to 2,500, 10 kw. from 2,500 to 5,000, and so on.

(5) *Water-Acid Test*—The specimens used for the water absorption test shall be brass rods 0.5 in. in diameter, 6 in. long, and carefully rounded at one end to a ball shape and polished smooth. These specimens, after thorough cleaning, shall be given three coats of varnish dipping so as to leave bare 1 in. of the rod at the end opposite the rounded end. Each coat should be allowed to drain for 1 hr. at room temperature, and then baked for ¼ hr. at 200 deg. F.

After last coat has been applied, the test pieces should be baked at least 10 hr., at 200 deg. F., and at least three specimens for each brand of varnish used should be made. They should be immersed for 4 in., not being allowed to touch the vessel containing the solution, in a solution of 1 gal. of distilled water to which has been added 1 oz. of pure sulphuric acid (H_2SO_4) at a temperature of 70 deg. F. The voltage drop between the solution and the brass rods should be measured immediately upon immersion and every 24 hr. after until failure, using 220-volt, direct current. Should specimens break down when first tested, they should be made. If three different specimens break down, the sample shall be considered as unsatisfactory. During the test the temperature of the solution should be kept at 70 deg. F. NOTE: A simple method of making the connections is to connect a voltmeter between each rod in turn and one side of a 220-volt direct-current circuit, the other side of the circuit being connected to the solution through any suitable piece of metal suspended in it. The resistance will be inversely proportional to the deflection of the voltmeter pointer; that is, the smaller the deflection the greater the resistance. Failure of the material will, therefore, be indicated by a sudden increase in the deflection of the voltmeter pointer.

The resistance between each rod and the solution should be measured once a day, and the number of days elapsing until breakdown occurs shall be taken as the resistance of the varnish to that particular medium.

(6) *Oil Resistance*—To test the effect of oil, use pieces cut from the dielectric strength test specimen, after they have been punctured and measured.

Immerse them half way in transformer or machine oil, at a temperature of 200 deg. F., and note time of softening until film may be removed by pressure and drawing through thumb and finger. Also, upon another piece the time required to cause blistering; this last piece should never be handled. The average of these two in hours shall be considered the oil resistance.

(7) *Aging Test*—Strips of muslin, which have been treated with the varnish in a way similar to the preparation of the paper strip in the drying test, shall be prepared and hung in the shop. A record should be taken every month to note any deterioration due to aging of the varnish.

(8) *Penetration Test*—Muslin shall be folded over until it forms about 40 layers. A 3/16-in. water gage glass containing about 6 in. of the varnish to be tested will be placed with one of its ends on the folder muslin and allowed to stand in vertical position for 30 sec. The depth of penetration of the varnish into the cambric will then be reported as the number of layers that the varnish has penetrated. V. A. PARTZ.

Consulting Engineer
American School,
Chicago, Ill.

Method of Drying Out Shunt Field Coils

A SHORT time ago several 250-volt, d.c., shunt-wound motors, ranging in size from 10 to 25 hp., were flooded. This occurrence, of course, necessitated the drying out of the motors and so the following method was employed:

A current was applied to the shunt coils at a lower voltage than that under which they would normally operate. As moisture will cause short circuits between the turns themselves at the normal motor voltage, it was thought advisable to start the drying out current at a low voltage, which could not burn the insulation even if there was practically a dead short between the turns. So 25 volts was considered a safe pressure at which to start the drying process. As the voltage was gradually increased, the temperature of the coils was watched so that their maximum temperature limit would not be exceeded.

This temperature was carefully determined by holding the bulb of a thermometer, under a piece of waste, tightly against one of the coils. To remove all the moisture in the coils in a reasonable length of time (in all probability less than 48 hr. will always suffice) a 75-deg. C. rise above the surrounding air was considered as high as it would be necessary to go.

Alternating current, when obtainable, is more effective than direct current, for the eddy currents set up in the pole pieces cause heating of the iron and bring the heat more directly in contact with the inside turns. In this case where so many motors are involved, it was most convenient to have one generator set aside for the purpose of supplying the drying out current, and the voltage regulated by varying the field current of this generator. Another plan that could have been employed, if a generator had not been available, would be to drive a 50-hp., shunt-wound motor as a generator.

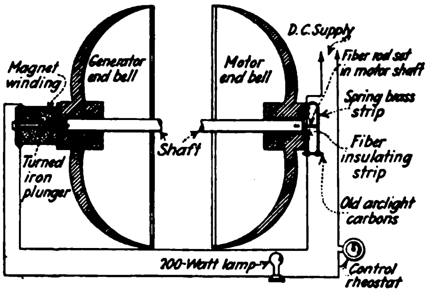
As the resistance of shunt field coils is quite high, they draw very little power; so the generator was used to dry out several motors at the same time. During the drying out process the motors were covered with tarpaulin.

ARTHUR F. HANLY.

New York, N. Y.

Preventing the Wearing of Grooves in Commutator

IN A plant, which I recently had occasion to visit, I noticed a very interesting method of preventing the brushes on the d.c. generator of a motor-generator set from wearing grooves in the commutator. This was accomplished by causing the armature and shaft to move slowly first toward one end of the generator and then toward the other. In this case it can be seen that the brushes are not allowed to make contact continuously in one place. Consequently the forming of grooves by the brushes is prevented.



This shows how a solenoid is employed to oscillate an armature shaft.

This sliding movement of the armature first toward one end of the set and then toward the other is caused by the shimming up of one end of the motor-generator set, which causes the armature to slowly slide by gravity toward one bearing, and when the armature has approached its limit of travel in this direction a contact is made which causes a magnet to be energized, and this magnet slowly forces the armature toward the high end of the set. When the armature approaches the higher end of the set, the magnet is de-energized and the armature again slowly slides by gravity toward the lower end of the set.

An electromagnet of the solenoid type was secured to the commutator end bell of the d.c. machine and inclosed in a suitable metal case to protect the windings from mechanical injury. On the outboard end bell of the induction motor there was a make-and-break device, actuated as shown in the accompanying diagram, that controls the current to the magnet by turning it on and off at the proper times.

The size of the magnet and corresponding parts will, of course, vary according to the size and weight of the parts to be oscillated, and it will be necessary to either shim the end bells to allow for the desired shift or turn down the oil flanges of the shaft.

This device for slowly oscillating the commutator has proven entirely satisfactory in this particular plant and I believe it will help to overcome some of the minor commutator troubles encountered in others. PHIL D. COMER.

San Bernardino, Calif.

How to Determine Reason for Reduced Speed of a Squirrel-Cage Motor

FREQUENTLY I am called upon to determine the reason for the slowing down of an ordinary induction motor. At such times the procedure that I generally employ is as follows:

First, ascertain if the voltage and frequency of the circuit are correct. In case the voltage is too low a decrease in the torque and consequently the speed of the motor will result. If the frequency is below the proper value, it would, of course, cause a corresponding decrease in speed. When both the voltage and speed are correct at no load, the motor itself should be examined next.

Look over the windings for short or open circuits. A short circuit will usually indicate its existence by causing the motor to take excessive current; also by overheating the insulation. In three-phase motors one of the phases might be inoperative, due to open circuits. In the rotor, especially in motors of the squirrel-cage type, there may be open circuits cutting out part of the winding, thereby reducing the torque. Also any loose connections in the rotor will increase the effective resistance of the rotor, and thus cause increased slip.

I have seen some cases where the solder used in connecting the end rings to the squirrel-cage rotor bars had been melted, and thus caused the rotor resistance to rise. The motor in such cases is rendered unfit for service until the rotor is repaired.

Should the windings prove to be satisfactory, next ascertain what load the rotor is carrying, for overloads will, of course, cause the motor to slow down. If the cause of the trouble still remains unrevealed, it will doubtless prove to be of a mechanical nature.

So the bearings should then be inspected to see if they are too tight, or the shaft is sprung or bent, thus causing excessive bearing friction. Should these points fail to disclose the trouble, the air gap of the motor should be checked. If the depth of the air gap is too great, there will be an abnormal leakage of flux and a corresponding reduction of speed and torque. An unequal air gap may be caused by worn bearings or by an incorrectly lined up armature. In either case there will be too large a gap on one side of the rotor, and too small a one on the opposite side. At times the rotor may be found enough off center to rub against the field punchings. H. J. ACHEE.

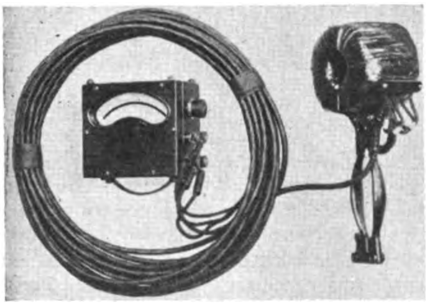
Superintendent
City Water & Light Dept.,
Woodward, Okla.

New Equipment
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Current Measuring Set

A SPLIT-CORE current measuring set for determining the load on feeders or distribution networks has been developed by the General Electric Co., Schenectady, N. Y. This set, which can be used for measuring the current flowing in a conductor without opening the conductor to insert an ammeter or a current transformer, consists of a



General Electric Pliers-Type Current Measuring Set.

transformer with a hinged magnetic circuit, leads, and one or more ammeters.

When taking a reading the transformer, which operates like a pair of pliers, is clamped around the conductor, with one hand. Flexible multi-conductor leads 50 ft. in length are supplied with each set.

Two sizes of transformers are supplied, one having a window opening of 1¼ in. and the other 2¼ in. in diameter. The former is rated 75/125/250-amp. primary, 2.5-amp. secondary, when used with a single indicating ammeter. A small indicating ammeter, Type P-8Y, is furnished. It has a cylindrical switch by means of which the various ratings of the set can be readily obtained without changing connections at either the transformer or the ammeter.

The recording instrument listed as standard with the sets is Type CRP-4, a portable, round-pattern instrument with an 8-in. diameter chart and one-day clock.

Forged-Cast Spur Gear

PRODUCTION on the Forged-Cast spur gear has been announced by The Hill Clutch Machine & Foundry Co., N. E. Corner Breakwater Ave. and W. Sixty-fifth St., Cleveland, Ohio. These gears, according to the manufacturer, consist of a forged-steel rim, in which the teeth are cut, with semi-steel cast hub and arms. After casting, the completed gear is finish machined and the teeth cut. It is stated that the junction of the steel rim and the semi-steel center is a laminated weld of steel and iron and the finished gear is one integral piece. The thickness of the forged rim is proportioned to the teeth. This process of combining a forged-steel rim and cast arm and hubs is also used for the production of flywheels.

Link Belt Conveyor Idler

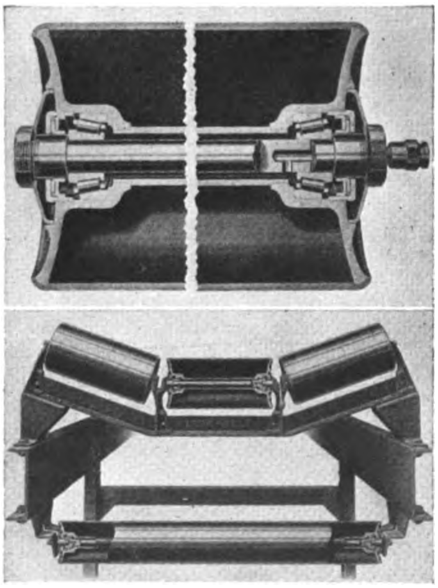
ANNOUNCEMENT has been made by the Link-Belt Co., Chicago, Ill., of the introduction of its anti-friction belt conveyor idler and return rolls.

One of the outstanding features of the idler is the protection afforded by a labyrinth grease seal, mounted in a grease cap which also serves as an outboard reservoir and lubricates the bearing on the outside as well as on the inside, especially when the roll is on an incline. This, in turn, is protected by a deflector plate which keeps dirt, dust, grit or any foreign material away from the bearings and grease seal.

The rolls are mounted on a self-cleaning "T" base and are interchangeable. The entire frame is riveted. The bearings are of the Timken tapered-roller type, which are totally encased within the roll hub.

It is claimed also that the design and construction of the roll make it practicable to vary the characteristics of the material used for the roll shell. Further, a special iron has been developed for use in coke plants, for resisting the corrosive action of sulphuric acid fumes and the abrasiveness of coke dust.

Link-Belt Anti-Friction Belt Conveyor Idler.

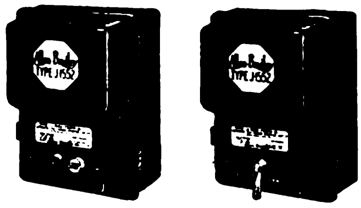


The idler rolls are supported in malleable-iron brackets having a large bearing surface and are not dependent upon the use of slots. The brackets are so constructed as to support the ends of two adjacent rolls, and the roll shafts are supported at both ends close to the rolls, without overhang.

Rolls are spaced far enough apart to permit convenient removal from the frame by simply lifting them out. The end stands, which are riveted to the "T" iron base, are spread at the foot to present a rigid support for the idler.

Across-the-Line Motor Switch

ANNOUNCEMENT has been made by the Allen-Bradley Co., 286 Greenfield Ave., Milwaukee, Wis., that it has recently added the Type J-1552,



Allen-Bradley Type J-1552 Form B Switch.

Form B switch to its standard line of across-the-line starting switches. The Form B size marks a new development in magnetic motor starting switches, it is stated, because it extends the advantages of push-button control, thermal overload relays, and no-voltage protection to the smaller sizes of motors that heretofore have been started only with knife switches. The new type J-1552, Form B switch is made for motors up to 1½ hp., thus bringing these small motors within the range of push-button operation.

The Form B switch is approximately 8 in. high, 6 in. wide and 4½ in. deep. The Form B-1 switch, shown closed, is equipped with start-and-stop push buttons in the switch cover. The Form B-2 switch is similar to the Form B-1 except that it is without push buttons. The Form B-3 switch, also shown, has a two-way lever switch for automatic and hand control.

Across-the-Line Starter for 5-Hp., A. C. Motors

DEVELOPMENT of the new C-H 9586 AAA starter shown in the accompanying illustration is announced by The Cutler-Hammer Manufacturing Co., 1,219 St. Paul Ave., Milwaukee, Wis. This new Cutler-Hammer product has been designed to handle motors of 5 hp. rating and under, gives push-

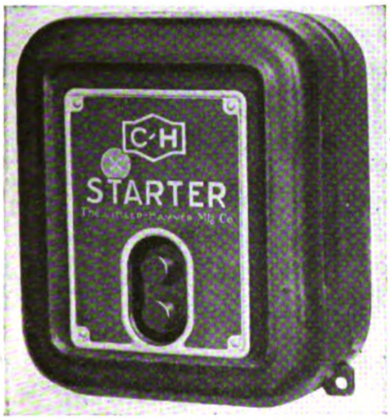
button control of starting and stopping, provides thermal overload and no-voltage protection and is no larger than a telephone box.

The small size permits mounting of the starter, in most cases, where the control station would ordinarily be placed. However, one or more push-button stations may be used if desired.

A novel feature is the type of contactor developed for use in this starter. A roller is forced between two fingers to complete the circuit; thus a double break and a wiping contact are secured. These fingers may be removed and new ones inserted without the use of tools. Ease of disassembly is one of the advantages claimed for the starter.

To adapt the starter for any horsepower within its rating it is only necessar,, it is stated, to insert the proper-sized heater coils in the thermal overload relay.

The overload relay is reset by pushing the stop button. The motor can then be started by pushing the other button, providing the overload has been removed so that the relay does not again trip.



Cutler-Hammer 9586 AAA Across-the-Line Starter.

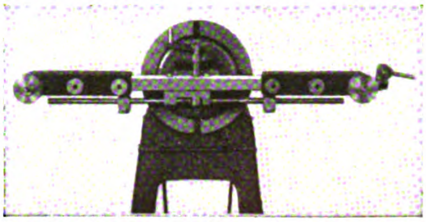
Loop Winder

THE Super Speed loop winder has been announced by the Armature Coil Equipment Co., 2,514 Forestdale Ave., Cleveland, Ohio.

A single lever movement draws in one slide block on a cam motion, allowing the loop to be removed from the pins. A spring tension returns the lever to the proper winding position and therefore prevents any possible chance of winding a short loop.

There are no catches or triggers, and the slide block or carriage, which is 9 in. long, gives a long bearing on the 1 in. x 2 in. flat bar on edge, thus preventing any chance of the bar springing. The extra length of carriage allows a 36-in. loop to be wound by using only a 30-in. winding bar.

The slide block has three positions to insert winding pins, making it possible to wind long or short loops, and the blocks are clamped by a split vise to each rod. One rod is controlled by a cam that allows the loop to be removed; the other rod, however, is held stationary.



Super Speed Loop Winder

The loops are started and finished in the same position and the two lead holders permit leads to be started on any side of the coil. These holders are of the revolving type and are quick acting. There are two sets of winding pins furnished; a quick snap-on set, and a screw-on set. The total weight of this set is about 15 lb. net.

Crane Trolley

ANNOUNCEMENT has been made by the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., of a new standard type crane trolley. The design includes a balanced drive, a straight-line construction in units each separately accessible, and an automatic oil bath lubrication.

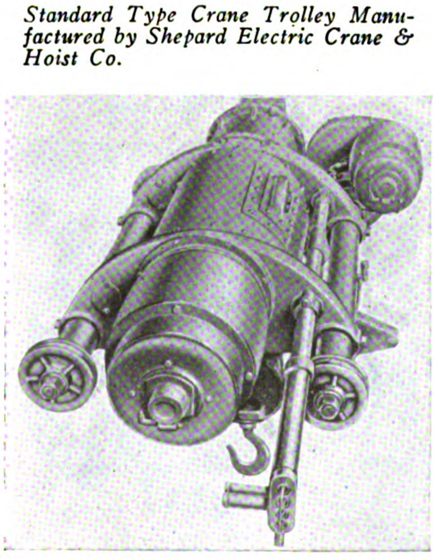
The construction of these crane trolleys in changeable sections permits each trolley to be built up of units particularly suitable for the service intended.

The frame is carried by axle brackets consisting of heavy seamless drawn steel tubes passing through bored openings in the girts, and the entire load-carrying structure from trolley wheels to winding-drum is of steel.

The trolley motor like the hoist motor may be mounted by bolting its field frame to an adapter, or as an alternative, upon its feet on a shelf near the center of the driven axle bracket. Any type of motor, solid or split frame of appropriate size, may be used.

The trolley axle bearings are waste packed and supplied with oil cellars communicating with a pool retained within the axle bracket tubes. Oil for all four bearings is supplied through a single pipe connecting both axle bracket tubes.

Standard Type Crane Trolley Manufactured by Shepard Electric Crane & Hoist Co.

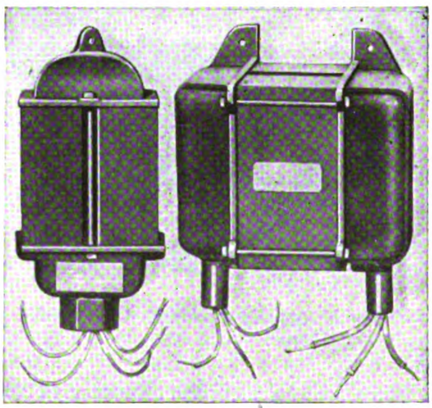


The trolley gearing, although similar to former designs, has been made more ample in size, permitting larger gears and gear ratios. The load block is fully inclosed.

Air-Cooled, Dry-Type Transformer

COMPLETION of engineering work and preliminary operation tests on the line of Trester air-cooled, dry-type transformers is announced by the Trester-Service-Electric Co., 55 E. Wells St., Milwaukee, Wis. Two of these units are shown in the accompanying illustration. These transformers are wound on cores built up of silicon steel, it is stated by the manufacturer.

The whole transformer core and windings after being assembled are treated in a high-grade insulating varnish and baked to increase the dielectric strength of the insulation and to prevent absorption of moisture. To protect the windings from mechanical injury, cast-iron shields are fitted and bolted to the cores. It is stated that, once installed, the transformers need no further attention and that the amount of power consumed, when not supplying a load, is negligible. Extra-flexible, rubber-covered leads are brought out and carefully marked to conform with standard practice. All splices are made in the terminal box which is attached to the bottom of the transformer. Conduits can be run directly to the box, thus eliminating all exposed wiring and at the same time grounding the transformer through this connection. The larger sizes of units from 5 to 20 kva. are equipped with standard conduit connections.



Trester Air-Cooled, Dry-Type Transformer.

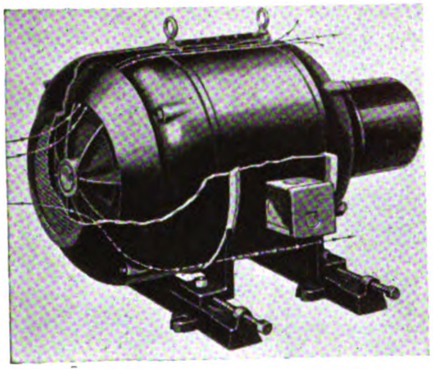
These units are made in ratings from ½ to 20 kva. Units up to 4 kva. are made of the type shown at the left. The larger sizes above 5 kva. are of the type shown at the right. A complete range of ratings listed is ½, 1, 2, 3, 4, 5, 6, 8, 10, 15, and 20 kva.

The type TRN is a two-winding or insulating transformer which is made

for single-, two-, or three-phase, 220- or 440-volt, 60- or 25-cycle primary. The Types TRNC and TRNS are single-winding transformers of the auto transformer type, and are made for single, two, and three phases. This unit is not recommended unless connected to a grounded primary system nor is it recommended for more than 240 volts. Type TRB is a balancing transformer of the single-winding type with a tap in the middle to convert 220 volts power circuit to 110 volts for supplying power for lighting circuits or operating other appliances. This Type TRB transformer is not recommended for lighting circuits where the electric code requires that the neutral must be grounded.

Self-Ventilating Motor

THE Howell Type K totally inclosed, self-ventilating motor has been announced by the Howell Electric Motors Company, Howell, Mich.



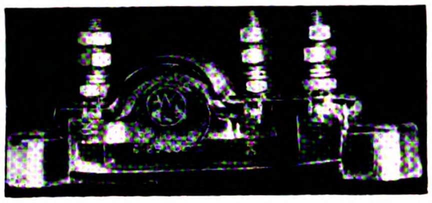
Type K Totally Inclosed, Self-Ventilating Motor.

This totally inclosed motor is of the external cooling type. The unit consists of a standard motor surrounded by a shell, which allows about ½-in. clearance between the shell and the motor. Air is forced at a high velocity through this space by a fan mounted on the motor shaft. In this way piping is eliminated—a motor frame only slightly larger that that employed in the normal motor can be used—cooling air does not enter the motor—foreign matter cannot get in the motor to injure or in any way impair or attack the windings—and, it is claimed, the costs are materially reduced over the ordinary totally inclosed motor. This motor is built with Timken roller bearings only.

Autovalve Arrester

TO GUARD low-voltage systems against insulation breakdowns, including failures of relays, transformers and other apparatus resulting in interruption of service, a low-voltage autovalve lightning arrester has been introduced by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

This arrester may be applied to alternating-current systems that operate at 65 volts or less and also on direct-current systems that operate at 45 volts or less. Some of the circuits to which this arrester may be applied advantageously include all manner of signal circuits, fire alarm systems, remote metering circuits and current transformer primaries.



Westinghouse Low-Voltage Autovalve Arrester.

The arrester is glass encased with clear moisture-proof glass, making every part of the arrester visible without removing the seal in the bottom. It is claimed that low resistance makes it possible for a discharge current of 1,000 amp. to flow through the arrester without causing any dangerous voltage across it. Leakage currents have been reduced to a minimum by the use of the autovalve principle and the moisture-proof glass case.

Hose Clamp

A NEW hose clamp has been introduced to the trade by the National Clamp Co., 16 East 41st St., New York, N. Y. From the illustration it may be noted that it consists of a band upon which is embossed a series of transverse ridges and depressions, forming in effect a toothed rack. The screw engaging with this toothed band is mounted on a trunnion.

In applying the clamp, the band is slipped over any part of the hose and compressed by hand. Allowing the screw to swing into position and taking a few turns with a screwdriver tightens the band. The screw, operating as a worm drive, feeds the band under the screw thread. This method of tightening the band, it is claimed, insures complete contact and equal pressure around the entire periphery of the hose.

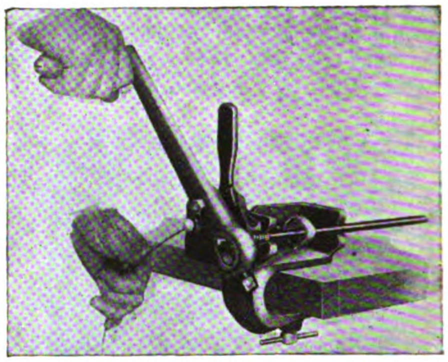
The clamps are made in four sizes: Nos. 10, 20, 30 and 40. Size No. 20, for example, will fit hose from 1 in. up to and including 1¾ in. inside diameter.

National Hose Clamp.

Spring Winder

A SPRING winding machine has been put on the market by the Fostoria Screw Co., Fostoria, Ohio. It is claimed that any apprentice can, with the device shown in the illustration, in a minute's time make a coil spring of any size from ⅛ to 1¼ in., using any gage wire from the finest piano wire to 3/16 in. It is designed to wind a right or left coil of any length and pitch, either of the compression or expansion type.

The size of the spring depends upon the size of the mandrel over which the wire is wound, while a tapered cam determines the lead or pitch. When the tapered cam is withdrawn from contact with the wire an expansion type of spring results. These rapid spring winders are furnished complete with large and small handles and also with a 1/16-in. mandrel and a wrench.



Spring Winder Manufactured by Fostoria Screw Co.

Alternating-Current Contactors

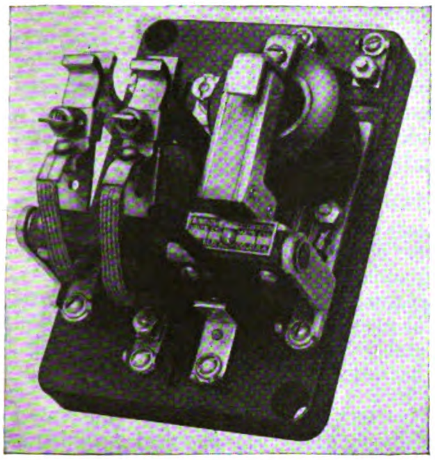
ANNOUNCEMENT has been made by the General Electric Company of Schenectady, N. Y., of a small alternating-current contactor for general application. It is self-contained on a molded base measuring 6½ in. x 4½ in., and two main poles rated at 15 amp. and a normally open interlock are provided.

This device takes from 3 to 6 watts and will, therefore, operate from a 50-watt bell-ringing transformer. Among the important features are the following:

A molded shaft is used. This is relatively new in contactor construction. The shaft bearing itself is of Bakelite and operates in bronze shaft bearings. The contactor bears the G. E. designation CR-2810-1332, and is made in four forms.

Form A is made with a short magnet gap, making it particularly suitable for thermostat control applications. This form is limited to 220 volts on the contact tips. Form B is made with a wider tip gap and is provided with a barrier between the tips. It has been given the following horsepower ratings: for 110 to 220 volts—2 hp., three phase;

for 440 volts—1½ hp., three phase; and for 550 volts—1 hp., three phase. Forms C and D are the same as Forms A and B respectively, except that they are back-connected. In this form the unit assembly is retained, but extended screws are used to permit mounting on a base for back-connection.



Small A.C. Contactors Manufactured by the G. E. Co.

Paint Spray Unit

A PAINT spray unit, known as the Milburn Type El siphon-feed outfit, has recently been placed on the market by The Alexander Milburn Co., 1416-1428 West Baltimore St., Baltimore, Md.

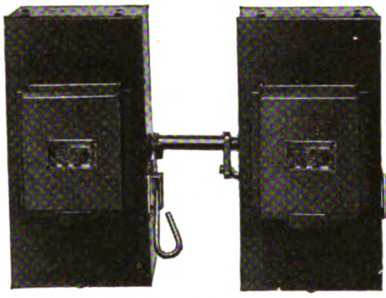
This unit consists of the Milburn Type E gun with a quart container, air purifier, air regulator, and 25 ft. of air hose with the necessary connections. An ordinary garage air compressor affords a sufficent volume of air to operate the gun.

As the air, upon entering the purifier, passes through a series of double baffles and moisture and other impurities are extracted from the air. The Type E1 outfit with the Type E gun furnished is adaptable to a wide range of painting, and it is claimed will operate efficiently whether using a heavy anti-corrosive paint or a very thin lacquer. The gun can be adjusted for such fine work as touching-up, shading and high-lighting larger work and for coarse work such as walls or ceilings. The atomized spray is surrounded by an air pocket which is designed to lessen the loss of material.

Alexander Milburn Paint Spray Unit.

Dual Service Switches

A NEW type of dual service entrance switch has been announced by the Palmer Electric & Manufacturing Co., of Cambridge, Mass. It is stated that dual service entrance control from duplicate feeders is provided for in capacities ranging from 30 to 400 amp., 250 volts, two, three, and four poles, by a recent addition to the Classification *AA* line of inclosed fuse switches manufactured by this company. The new switch consists of two standard Classification *AA* fuse switches provided with a mechanical interlock that permits either one of the two services to be connected to load. Each service connection is fused and inclosed in a separate switch cabinet.



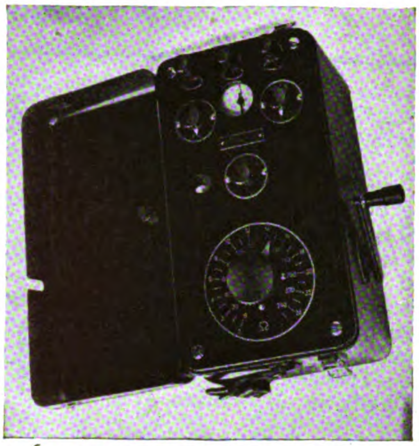
Dual Service Switches Made by Palmer Electric & Manufacturing Co.

Ohmmeter

A NEW measuring device known as the Ground Ohmer is a Siemens & Halske product, and Herman H. Sticht & Co., 15 Park Row, New York, N. Y., are the exclusive sales agents for the United States. This direct reading portable ohmmeter is a compact unit, which, as illustrated, is entirely self-contained.

A hand-operated 35-cycle generator is used as a source of current for feeding the current transformer, which has two windings in the ratio of 1:1 and 1:10. These ratios enable the bridge to be adjusted over a range of 25 ohms or 250 ohms.

The galvanometer is of the shielded dynamometer type, and a noteworthy feature of the device is the zero adjuster of the moving system of the galvanometer. This adjustment is designed to offset the influence of stray currents. The screw anchor, or other ground devices, are placed 20 and 40 yards away from the resistance to be measured.



S & H Ground-Ohmer.

Outdoor Switchhouses

SEVERAL changes have been made by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., in the past three months in the design of its new outdoor switchhouses.

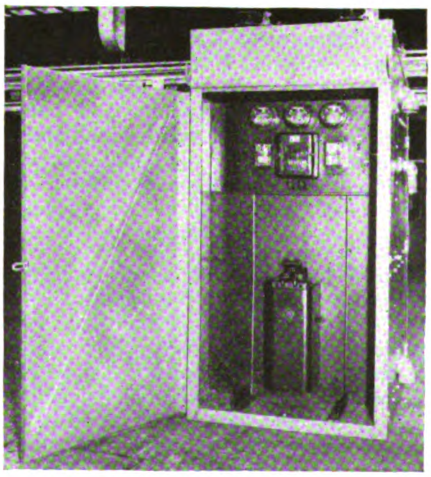
In addition to the most prominent change, the reduction in height, which gives a more compact single unit and also allows ready mounting under existing structures and buses, there is another very desirable feature—the complete isolation of the front from the rear of the houses without decreasing accessibility.

As the meters and relays are now mounted on steel instead of slate panels, additional bracing is provided to the houses by this arrangement and the possibility of any panel breakage is thereby eliminated.

The circuit-breaker control relay is mounted in a glass case to remove all danger of anyone coming in contact with live parts in the front of the switchhouse.

This enables the central stations to utilize the services of a more or less inexperienced man to obtain meter readings.

Westinghouse Outdoor Switchhouse.



Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Air-Cooled Transformers—The line of Trester air-cooled, dry-type transformers rated from ½ to 20 kva. are described and illustrated in Bulletin 527. This line includes two-winding or insulating transformers, single-winding or auto transformers and balancing transformers.—Trester-Service Electric Co., 55 E. Wells St., Milwaukee, Wis.

Rebuilt Equipment—The monthly Bargain Sheet lists and prices various units of Hi-Grade-Rebuilt motors, generators, motor-generator sets, transformers, meters, and other electrical equipment.—Gregory Electric Co., Sixteenth, Lincoln and Wood Sts., Chicago, Ill.

Copperweld Products—A folder gives the various types of Copperweld products and indicates in tabular form the various uses which are made of them. —Copperweld Steel Co., Braddock P. O., Rankin, Pa.

Speed Reducer—Book 630 illustrates the construction and gives specifications for the two new types of Caldwell speed reducers, which are especially designed for use in connection with conveyor and elevator service and for screw conveyors.—H. W. Caldwell & Son Co., Western Ave. at Seventeenth and Eighteenth Sts., Chicago, Ill.

Dust Collecting—Bulletin 9 (revised) describes the Draco dust collecting installation at the cement plant of the Ford Motor Co.—The Dust Recovering & Conveying Co., Harvard Ave. & E. 116th St., Cleveland, Ohio.

Oilless Bearings—A folder contrasts the application of ordinary bearings on loose pulleys with Arguto oilless bearings on loose pulleys.—Arguto Oilless Bearing Co., Wayne Junction, Philadelphia, Pa.

Self-Threading Unions and Connectors—Bulletin 2098 describes and illustrates applications of the Crouse-Hinds self-threading unions and connectors for use in connecting fixed runs of conduit or bent or offset sections which would be difficult to screw into a condulet.—Crouse-Hinds Co., Syracuse, N. Y.

Line Protection—A recent issue of the monthly publication entitled "The Line" describes a porcelain-inclosed throttle fuse and a 90-deg. gravity stop. The latter, it is said, allows the blade of an indoor, vertical-mounted, double-throw or selector switch to be held in a rigid, open position, thus eliminating the possibility of the open blade falling upon the lower contact. The catch is of such construction, however, that the switch blade can be thrown into the lower contact, if desired.—Line Material Co., South Milwaukee, Wis.

Excavator and Crane—Bulletin BH-1 describes the P & H Groundhog, Model 300, which can be used as a ½-cu.yd. shovel, dragline, clamshell, crane, or pile driver by changing the boom and attachments. This all-around. full-revolving unit is mounted on corduroy treads.—Harnischfeger Corp., Milwaukee, Wis.

Electric Tools—A loose-leaf catalog illustrates and gives specifications for the various Standard electric drills, grinders and other tools manufactured by this company.—The Standard Electric Tool Co., Cincinnati, Ohio.

Cable End Bells—Bulletin 20 gives specifications and dimensions of the line of indoor cable end bells.—Electrical Engineers Equipment Co., Melrose Park, Ill.

Tramrail—A 64-page catalog describes the Atlas Duo-Rail track and carriers and illustrates a large number of installations. This is a double-rail tramrail system.—The Atlas-Chicago Co., Division of Chicago Electric Co., 740-744 W. Van Buren St., Chicago, Ill.

Industrial Lighting—Numerous installations of X-ray reflectors in industrial plants and considerable lighting data are given in serial 448.—Curtis Lighting, Inc., 1119 W. Jackson Blvd., Chicago, Ill.

Elevators—Book 680 devotes 44 pages to a discussion of modern types of elevators for handling various loose materials and gives a discussion on how to select an elevator. A table indicates the type of elevator to use for handling various materials.—Link-Belt Co., 910 So. Michigan Ave., Chicago, Ill.

Variable-Speed Control—Bulletin describes the push-button electric remote control which is built into the Reeves variable-speed transmission unit.—Reeves Pulley Co., Columbus, Ind.

Battery Trickle Chargers—Booklet TC-8 describes the trickle method of charging storage batteries and illustrates the Balkite line of trickle chargers, now available for industrial service. The two new compact unit types RA and RB for alarm, signal, telephone, and switch-operating batteries are fully described. This booklet will be especially helpful to those not familiar with the trickle charging principles.—Fansteel Products Co., North Chicago, Ill.

Flexible Coupling—The Sykes universal shaft coupling, which is used for compensating for misalignment between connected shafts, is illustrated in a folder.—Farrel Foundry & Machine Co., Buffalo, N. Y.

Industrial Mesh—A group of circulars illustrate a few of the numerous uses of Steelcrete industrial mesh, an expanded metal, for guards, screens, inclosures, and numerous other industrial uses.—The Consolidated Expanded Metal Companies, Steelcrete Bldg., Wheeling, W. Va.

Aluminum Paint—An illustrated handbook gives the physical properties of aluminum paint and discusses the opportunities for its use in modern industry. Composition, characteristics, and special properties of aluminum paint are covered in detail.—Aluminum Company of America, Pittsburgh, Pa.

Brakes—Bulletin 1004 illustrates and describes the E C & M type WB brake for steel mill applications. The method of removing a motor armature and brake wheel is illustrated.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Gears—The pocket-size catalog 47 gives specifications and prices on the standardized gears, chains, and speed reducers carried in stock for immediate delivery at the Boston Gear service stations.—Boston Gear Works Sales Co., Norfolk Downs, Quincy, Mass.

Tiering Machine—A folder illustrates and gives specifications for the various Standard electric and handpower types of tiering machines.—Standard Conveyor Co., North St. Paul, Minn.

Motors—A 16-page booklet illustrates and describes the various Janette standard motors of 1/30 to ½ hp. for alternating or direct current.—Janette Mfg. Co., 556-558 W. Monroe St., Chicago, Ill.

Silent Chain—A circular entitled "Improving Power Transmission" illustrates applications of Ramsey silent-chain drives in industrial plants.—Ramsey Chain Co., Inc., Albany, N. Y.

Steel Stringers—A folder illustrates from photographs and sketches the application of Midwest steel stringers for supporting lineshafts and other overhead equipment.—Midwest Steel & Supply Co., Inc., 100 E. Forty-fifth St., New York, N. Y.

Soldering—An interesting 29-page booklet entitled "Facts on Soldering" gives valuable information on fluxes, solders, soldering equipment, and the application of solders and flux.—Chicago Solder Co., Chicago, Ill.

Volume 85 New York, September, 1927 *Number* 9

INDUSTRIAL ENGINEERING

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

Application and Operation of Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

G. A. VAN BRUNT, *Editor*

D. H. BRAYMER
Consulting Editor
A. J. WHITCOMB
Contributing Editor

F. E. GOODING
G. H. FAIRBANKS
Associate Editors

Contents

Departments

Our New Name

Announcement is made elsewhere of the changing of our name to Industrial Engineering, effective with this issue.

Industrial Engineer was founded to serve operating men and other executives who are responsible for the proper application, operation, and care of industrial electrical and associated mechanical systems as only a publication devoted to the thorough discussion of practical operating problems can serve them. By strict adherence to the ideals and policies that were laid down months before the first issue was published, Industrial Engineer became the clearing house for the practical information that operating men need and use in their daily work. In its columns these men have discussed their problems and given freely of their knowledge and experience for the benefit of other plant men.

The change of name to Industrial Engineering will not affect our general editorial policy. This publication will continue to be filled with the helpful information and practical discussions that have won for it a place on the desks of thousands of operating men. However, plans have been made for enlarging and extending our service by studies and thorough discussions of some problems and phases of plant operation that have heretofore received less detailed treatment.

Industrial Engineering is going to be more indispensable than ever to operating men confronted daily with important problems whose solution is oftentimes to be found only in the recorded experiences of other men who have met and solved the same problems.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

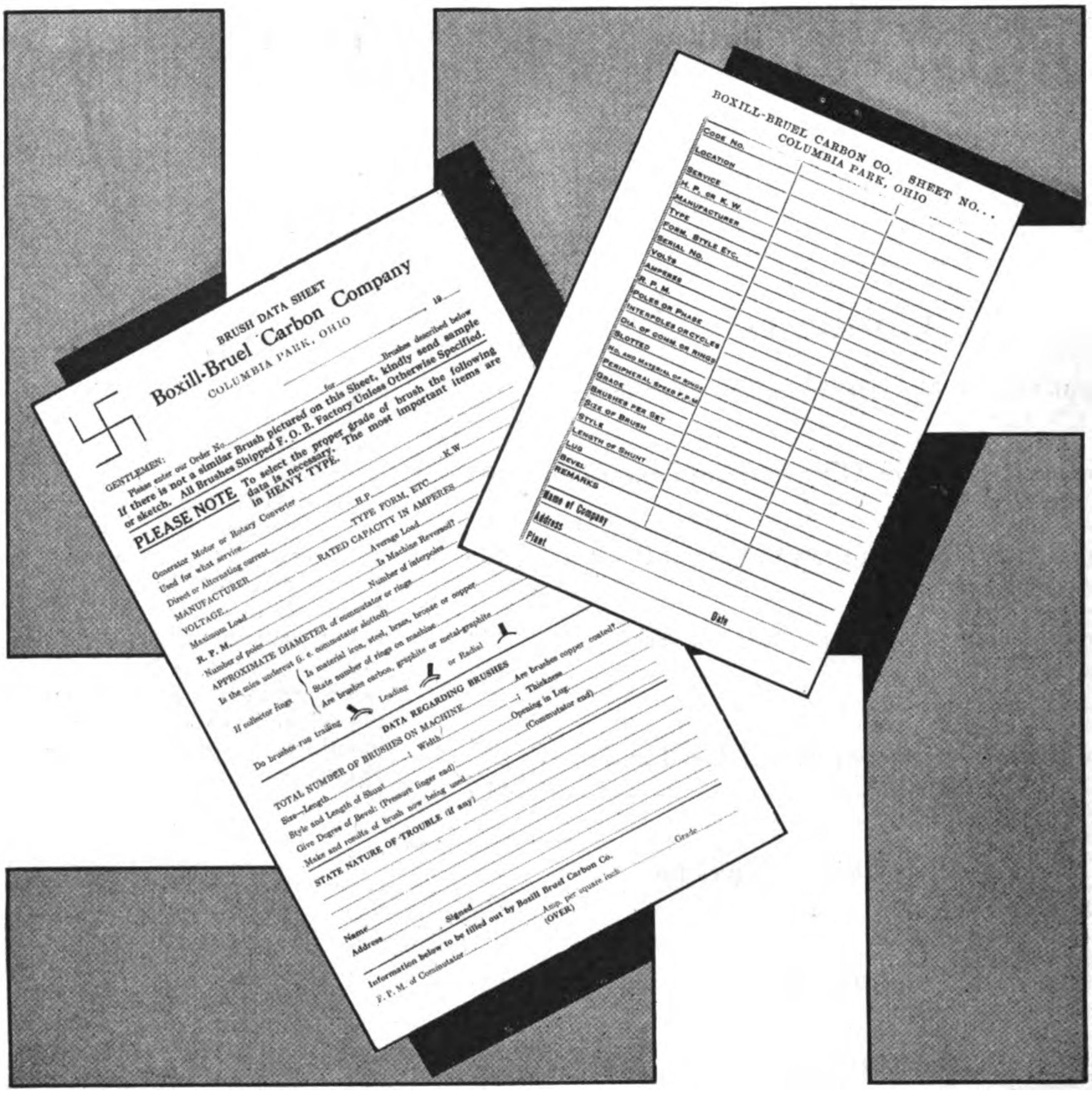
WASHINGTON, National Press Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4

Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

NEW YORK District Office, 285 Madison Ave.
Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record — American Machinist
Power — Chemical and Metallurgical Engineering
Coal Age — Engineering and Mining Journal
Coal Age News — Electrical Merchandising
Ingeniería Internacional — Electric Railway Journal
Bus Transportation — Construction Methods
Electrical World — Radio Retailing
Industrial Engineering — Electrical West *(Published in San Francisco)*
American Machinist—European Edition *(Published in London)*

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879



You can't guess—
if you want reliable brush service

Boxill-Bruel found this out early in the business and immediately began to render an entirely different type of service than was known just a few years ago.

Brushes to give efficient, long life service must be adapted to the job. A complete record of each installation, a history of past performance and a thorough knowledge of the type of brush required for each installation has enabled us to clear up motor troubles that were not only irritable but costly.

The two forms illustrated properly filled out will start you on the road to Boxill-Bruel service. It costs you nothing to get the facts. Write for sample sheets.

BOXILL-BRUEL CARBON COMPANY
COLUMBIA PARK, OHIO

Helps for the Engineer—Check

Please send me—

- ☐ Engineering Data Sheets.
- ☐ Code Sheets.
- ☐ General Catalog.

NAME...

FIRM...

ADDRESS..

INDUSTRIAL ENGINEERING

Application and Operation of
Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

Volume 85 — **New York, September, 1927** — *Number 9*

An assembly conveyor not only carries the work from one man to the other, but makes it possible for the men to specialize on certain operations.

Methods of Solving

Material Handling Problems

By D. B. KIFT
General Superintendent
Edison Electric Appliance Co., Inc.,
Chicago, Ill.

ALL operating men do not have the same conception of what can be done toward lightening the burden of material handling in the average industrial plant. For example, in many instances practically all of the attention is given to the possibility of using some other or larger machine or equipment for doing the handling when much greater, as well as more important and worth-while gains, would result from as close a study of the possibilities of entirely changing the plan of handling.

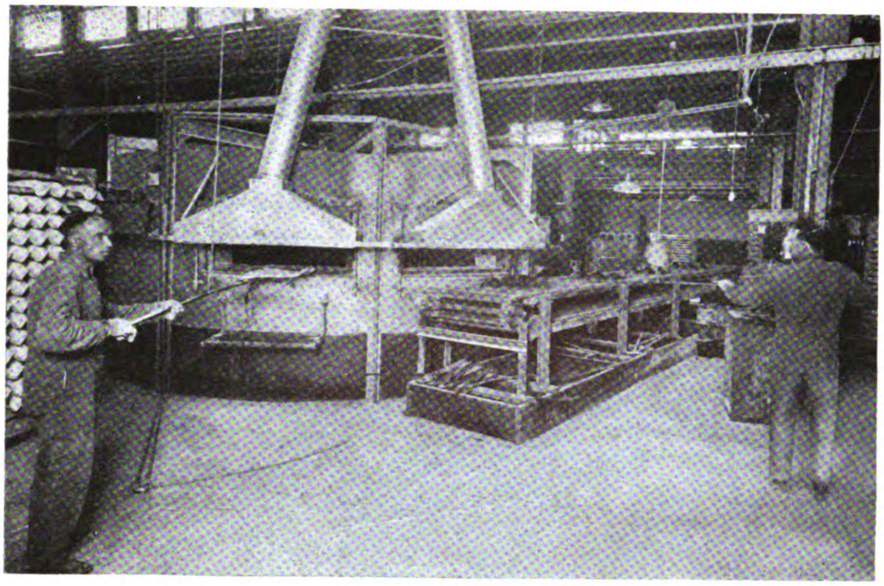
Material handling has a much broader meaning than the movement of materials into and out of stock and to and from machines. Increasing the size or quantity of units handled at a time is one method of improvement; another is to tie the handling in with the process, or to combine several steps of a process to eliminate handlings between steps.

Many plants are adding considerably to their handling costs by many needless rehandlings. However, the wide use of the lift truck and platforms has done much to eliminate this last item of waste.

Some of these points can best be explained by picturing the steps we have taken to overcome difficulties in handling materials of various kinds.

Our main plant is engaged in the manufacture of electric ranges and refrigerators, which are largely of sheet metal construct[illegible] and are rather bulky when asser[illegible] and of the line of Hotpoint e[illegible] household appliances, such as [illegible] irons, heaters, and so on.

Before going further, it may be well for me to explain our policy regarding the purchase of material handling or other devices or equipment, which might be termed specialties. We do not believe in spending money for such equipment unless it will save its cost in a very short time —within a year or less—because there



This shows circular enameling oven with cooling conveyor.

Legs for ranges and refrigerators are placed in a circular oven by the man at the left. The man at the right moves them after they have made a complete revolution and places them on the slat conveyor at the right for cooling. This oven is operated by a Reeves variable-speed drive through a Foote worm speed reducer, which permits a wide variation in the length of time different products remain in the oven.

is so much equipment that may be purchased, or devices that may be made, which will save their cost in less than a year. We have always found enough of these items obtainable to use up all our appropriation. Naturally, the opportunities for investments with such quick returns are becoming scarcer and consequently we are increasing the limit. This policy, of course, does not extend to machine tools or other necessities for production.

Material handling begins with the receipt of the raw material, although we have found that many of the largest savings can be made during the manufacturing processes. Strip steel is received in boxes and is handled from the car to the storage warehouse on a short length of gravity roller conveyor. A hoist on an oval monorail track is used to pile the boxes in two rows, one under each of the two sides of the oval. The boxes are not turned as received, but go straight into the stockroom from the car and are moved to the right or left into position on the pile by the hoist, which is also used for lowering these boxes from the top of a high pile onto the lift-truck platforms when they are to be distributed to the various machines.

Larger sheets of steel are loaded loose from the cars on to short lengths of portable gravity roller conveyors which carry the sheets directly to the pile. It is thus necessary for the men only to straighten the sheets on the pile as they come off the conveyor. Handling, that is lifting and carrying, is practically eliminated.

The cost of these roller conveyors is practically nothing compared to what they will save in the cost of handling even a few carloads of steel, if the steel had to be carried the same distance, or loaded, hauled, and unloaded.

The sheet steel is handled to the various machines on Barrett-Cravens hand-lift trucks with extra long platforms. In addition, these hand-lift trucks are used practically altogether for handling material between machines, to inspection, and to the storeroom. We never unload a platform unless it is absolutely necessary to do so. Most of the work in process is transported in tote boxes because extra platforms to hold these are much cheaper than the rehandling which a shortage of platforms would entail.

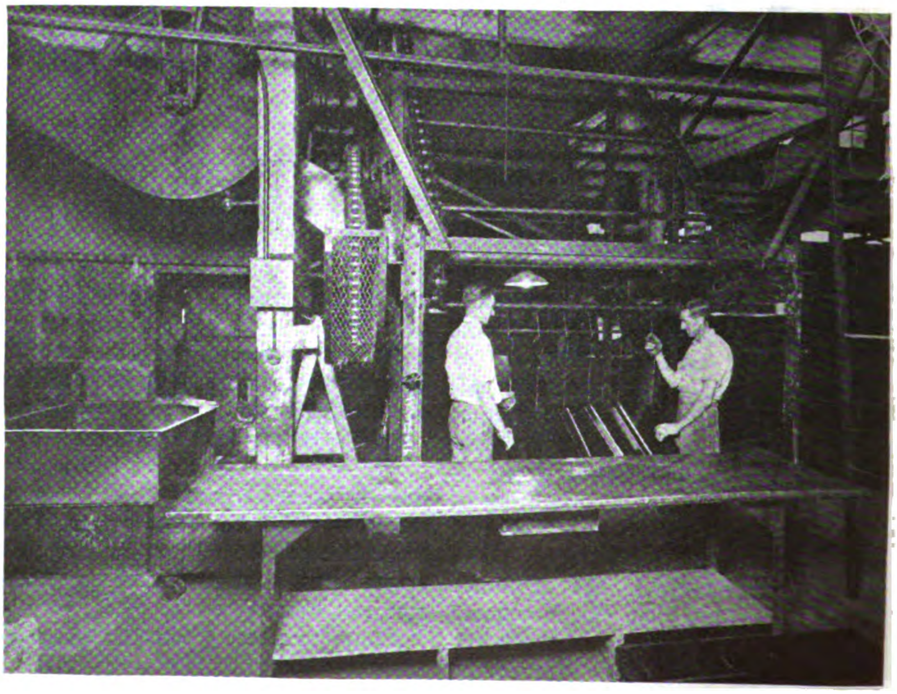
We are standardizing on a single size of tote box which, I believe, will also simplify our handling problem. At present we have two sizes. The larger is too heavy to handle in and out of shelf storage when filled. When all of the larger boxes are worn out, the spacing of the steel shelving will be changed to fit the smaller box and the quantity of each item placed in a tote box will be standardized to the quantity of that unit usually issued at a time, so that the stores department can issue parts for assembly by the tote-boxful without stopping to recount, which makes considerable saving in time.

Some of the work, particularly that with a finished surface, is handled on platforms or trucks with a special superstructure. One of these is shown at the left in the illustration of the circular enameling oven, on this page.

Large savings have been made

The discharge end of the japanning oven.

Parts which can be japanned by dipping are hung on a crossbar of this conveyor at the other end of the oven. The conveyor zigzags up and down and carries the parts through the benzine cleaning tank, through the japanning tank, and into the baking oven. Provision is made for attaching parts which must be baked but cannot be dipped. This conveyor, although one of the most expensive pieces of equipment in the plant, paid for itself in less than seven months.



Special facilities are provided for handling refrigerator bodies during assembly.

For example, the inclined turntable at the right is used when welding seams so that the operator can turn the refrigerator easily during the welding process. Barrett-Cravens hand-lift platform trucks are used to handle heavier material throughout the plant.

through the elimination of handlings and rehandlings between the manufacturing operations and processes. Much of this has been done by tying together several related steps in the manufacturing operations, generally by means of some type of conveying equipment.

An example of this was the installation of a continuous belt to carry the sole plates (the heavy bottom plates) in electric irons, past an automatic drilling machine, and then past an automatic tapping machine. This belt extends about 3 ft. at each end past the machines, which gives sufficient operating space for one man to insert sole plates at one end of the belt and remove them at the other.

With a shorter belt two men, one at each end, would be required and the machining operations could not be speeded up any faster. In other words, there would be very little saving, because two men could operate the two machines almost as fast. The saving is obtained in the elimination of one operator and the handling *from* the first machine and *to* the second machine, practically one-half of the total handling.

The more steps that can be tied together, the greater is the saving. Of course, as the length of this belt is increased, a point is soon reached where one man cannot take care of both ends but, at the same time, a larger number of handlings should be eliminated or the device will not pay for itself.

One of our most expensive pieces of equipment in first cost and, incidentally, the one making the largest saving, is built on this same principle. This is the continuous japanning equipment, the discharge end of which is shown in the illustration on page 398. Even as expensive as this unit was, it paid for itself in about seven months.

This unit consists of a large Link-Belt roller chain conveyor built to carry the parts to be japanned, which are hung on crossbars. Instead of the parts traveling in a straight line, the conveyor is constructed to zigzag up and down. Although the total length of the conveyor on the floor is but 150 ft., the parts are carried about 225 ft. at a speed of 2 ft. per minute.

Parts which can be dipped are hung on a crossbar which is picked up by the conveyor, carried up and then lowered into the benzine cleaning tank. They are then zigzagged up and down into the drying chamber, where they are dried in warm air. From there they are passed up and down into the japan tank and from there are conveyed to the dripping chamber.

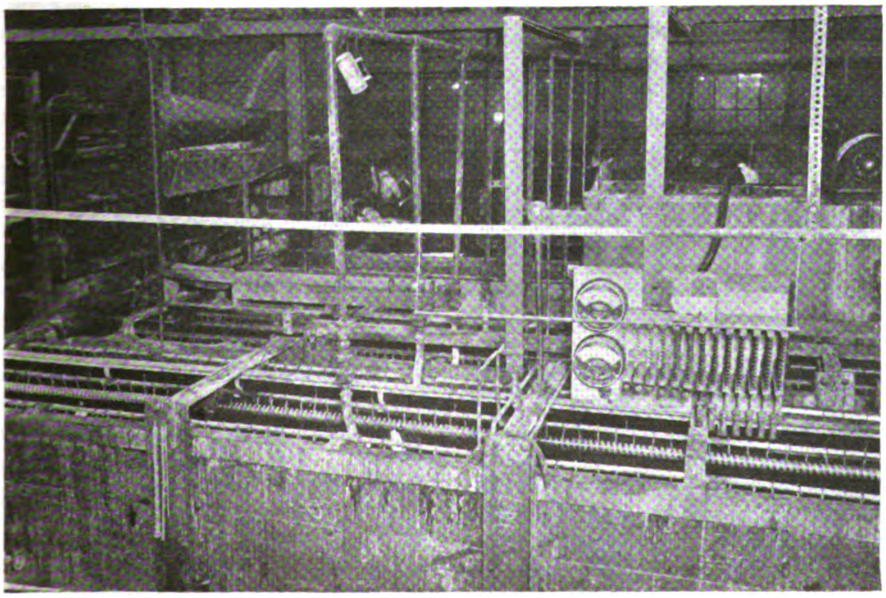
The chain then passes down near to the floor level to pick up parts that cannot be dipped, such as ovens that are sprayed with japan on the outside only, and then on through the baking oven, which is kept at a temperature of 450 deg. F. The benzine tank is protected by Fire-Foam sprinkler heads located over the center of the tank, with other heads on each side. A rapidly rising temperature in the benzine tank would open these heads, discharge the Fire-Foam and smother the fire.

The only handling required is in loading and unloading the conveyor, in contrast to the handling between the steps which would be necessary if this equipment and the various processes were not tied together in this way. In addition, a much larger amount of space would be necessary for storage between operations.

This conveyor is driven at constant speed by a high-speed motor through a belt, a Foote worm speed reducer and two roller-chain reductions. The chain on the conveyor is kept lubricated by a wiping lubricator. A

Handling material in the plating room.

Parts are cleaned before plating, while on the special conveyor which alternately dips the parts and allows them to drain. Thus the only handling involved is in placing the parts on the conveyor at one end and taking them off at the other. The parts, still on the hooks, are then hung on the screw conveyor in the plating tank. The rotating screw carries them the length of the plating tank in 12 min.



special japanning-oven lubricating oil, which will stand up in the high temperature, is used.

The cleaning baths in the plating room are also operated in conjunction with a zigzag conveyor which carries the parts in and out of the cleaning and washing solutions. Handling in and handling out between the operations is thus taken care of automatically. This cleaning conveyor is driven at a constant speed by a motor belted to a Foote worm speed reducer.

The parts are removed from the last cleaning tank and hung on a rotating worm screw which carries them through the plating solution, as shown on page 399. These screws are driven through gears at a speed which will carry the parts the full length of the plating tank in 12 min.

Industrial men who have never had any experience with assembling on conveyors cannot appreciate their full worth. The illustration at the head of this article shows a part of our electric range assembly conveyor, which is 205 ft. long. This is a Palmer-Bee slat conveyor driven through a Palmer-Bee worm reducer by a variable-speed motor. Four speeds may be obtained through a drum controller which will drive the conveyor 10 ft. in 7.6 min., 5.2 min., 3.8 min., or 2.5 min. respectively. The speed is selected according to the model of range being assembled, the scheduled output, and the number of men working on the assembly line.

This method of assembly has been used in automotive and many other lines of industry and has been described so often that it will not be elaborated on in detail here. However, plants which have products adapted to assembling on conveyors will find this method one of the biggest savers of handling time. The work simply passes from one man to the next without his having to pick it up, set it down, or even move it, except at a few places in the assembly where the work must be turned. The amount of time spent in picking up work and setting it down is seldom realized until it is actually measured.

The circular vitreous enameling oven, also illustrated on page 398, makes the handling of work in and out a continuous process instead of the intermittent operations of loading, waiting until baked, and then unloading, with the oven idle during the loading and unloading time and the men idle during the baking time.

This oven is driven by a Reeves variable-speed transmission through a Foote worm speed reducer to give a variation in the time of rotation from $1\frac{1}{2}$ min. to 9 min. so that it is adaptable to a large variety of work.

The enameled parts are removed from the conveyor and laid on the slat conveyor at the right to cool.

This conveyor travels at a speed of 6 ft. per min. and by the time the parts reach the end, they have cooled enough to be handled with asbestos mittens.

Use of Welding in Resurfacing Wearing Parts to Resist Abrasion

ABRASION is one of the most serious problems for industrial opearting and maintenance executives in many industries. This is particularly true in such industries as cement manufacturing, where metal parts of pulverizing, grinding, crushing and conveying machinery are worn out in a short time through abrasion. In a paper presented recently before the New York Section of the American Welding Society, A. V. Harris, Haynes Stellite Co., New York, N. Y., gave some interesting details of the results obtained by several plants in this industry that have successfully tried welding a coating of Stellite on the wearing surface.

Stellite is not a steel, but an alloy of cobalt, chromium and tungsten, and is produced in an electric furnace. It is a hard metal that resists abrasion, heat and corrosion, requires no tempering, and is cast to form; it can be finished only by grinding. This metal is widely used in cutting tools for machining metal.

Recently, however, considerable attention has been given the use of Stellite for surfacing in maintenance work, and a number of practical applications have been made of depositing it by means of welding equipment, on a surface subject to abrasion. It is said that it can be applied without heat treatment to copper and to any grade of steel, including carbon and alloy steels, and to practically any cast-iron surface.

For this coating or Stelliting, as the process is called, the alloy is provided in the form of welding rods. The surfacing, however, calls for a slightly different technique than most acetylene welding in that the process is neither welding nor brazing in the ordinary sense of these terms. For example, when welding, the surface of the base metal is brought up to the flowing point and the Stellite welding rod is then puddled and fused with the molten base metal.

Stelliting calls for blowpipe flames that contain a fairly large excess of acetylene to lower the flame heat and to exclude as much atmospheric oxygen as possible. The surface of the base metal to which the Stellite is to be applied is brought up to such a heat that it just begins to sweat and assumes an oily appearance. The lightest possible penetration into the parent metal is most desirable, since this eliminates the possibility of an undesirable alloy being formed with the Stellite.

At this point the Stellite is melted from the rod and allowed to flow on to the base metal with as little agitation as possible. The action when flowing on to the steel is similar to that of solder flowing from an iron on to a tinned surface. Examination of a Stellite weld made in this manner shows that practically no penetration into or alloying with the base metal has occurred. This coating may also be applied with the electric carbon or metallic arch process, it is stated.

Stellited metal parts, when used in pulverizing, grinding, crushing and conveying machinery in the portland cement industry, have a greatly increased life. A screw conveyor of the conventional type when coated on the periphery has, it is said, lasted six times as long as a heat-treated carbon-steel screw. A special surface $\frac{1}{8}$ in. thick on a gudgeon as used in the cement plant will give that part a life three times as long as $\frac{1}{2}$ in. of steel.

Hot drag chain supports, conveyor buckets and cams, steam shovel dipper teeth and roll mill plows may also have their life increased by thus coating the wearing surface. The combination properties of resistance to heat and resistance to abrasion are utilized in hot-drawing and hot-forming dies with an increase of three to five times in their life. The die is called upon to resist the heat of the metal that is being formed and the abrasion of this metal as it is drawn.

In the manufacture of dry cells or dry radio batteries a number of dies and machine parts, come in contact with active chemical compounds that tend to corrode and destroy the metals used. Their life by coating may be increased because of the ability of this alloy to resist corrosion as well as abrasion.

Speed Reducers

Some of the inherent limitations that must be considered when applying these devices to industrial power drives

By C. H. GRILL
Chief Engineer
Philadelphia Gear Works
Philadelphia, Pa.

UNIVERSAL use of the electric motor in the industrial plants of today has brought with it many innovations. This source of mechanical energy is compact, efficient, and applies the power at the point needed, but it has the inherent characteristic of operating at comparatively high speeds. In many cases these speeds are entirely too high for industrial purposes, and consequently some medium must be interposed between the motor and the driven machine that will step down the high motor speeds to the more suitable operating speeds.

This is admirably accomplished through the aid of a modern speed reducer. Of the many types of this equipment on the market at present, the most popular are the worm-gear and spur-gear types, although the herringbone type is preferred for the larger and heavier drives. These various types have been largely standardized so that they are available in suitable sizes and ratios for almost any power and speed reduction required.

It is the purpose of this article to point out the inherent limitations of these devices so that a prospective user of this equipment may make a proper selection to suit his particular requirements.

The trade catalogs in most cases list the ratios and the ratings, that is, the horsepower and speed, for which the speed reducer is designed. In a large majority of cases the rating represents the power capable of being transmitted when the materials of which the machine is composed are stressed to the maximum safe stress allowable; consequently no reserve for shock, overload, reversals or loads from outside of the machine exists, and the unit should be selected with a factor of safety which naturally varies with each individual installation. The question of efficiency also enters into the selection of a speed reducer, as there is no means yet extant of transmitting power without some power loss. It may be said that, in general, the greater the reduction, the greater the power loss.

One of the most important factors in the successful operation of a speed reducer is the connection to the motor, as well as the connection of the slow-speed shaft to the shaft of the driven machine. Flexible couplings are of paramount importance at these points. It is virtually impossible to line up two shafts, each supported on its own bearings, so that both will revolve about the same axis. Unless a flexible coupling is used, between the shafts, the bearings on motor, speed reducer and driven machine are subjected to extremely severe loads, for which they were not actually designed.

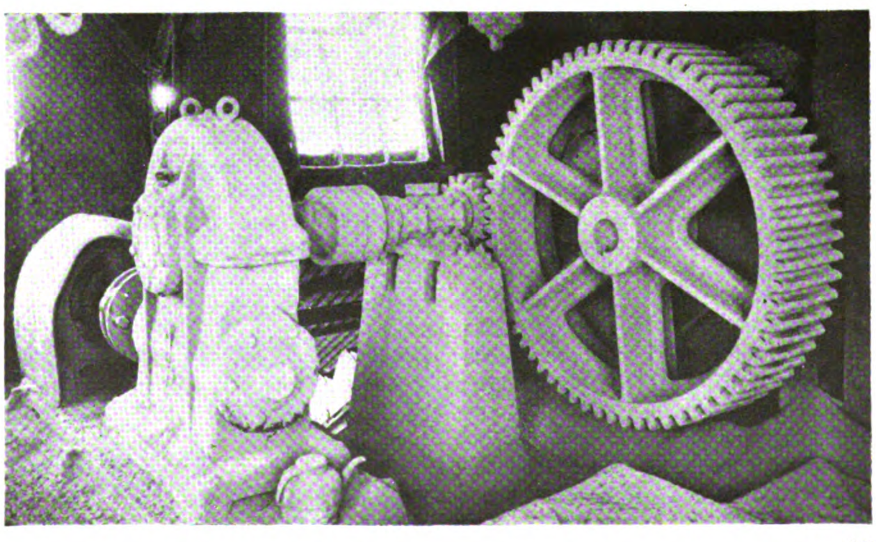
A flexible coupling is also subject to abuse; it should be applied only to shafts that are as nearly in line as possible. Where this condition does not exist a universal joint should be used. However, the arrangement employed by one user should be avoided: A flexible coupling was used between the speed reducer and the driven shaft, according to the manufacturer's recommendation, but a spur pinion was mounted next to the coupling and only one small bearing was provided on the other side of the pinion. The final result—early failure—was a foregone conclusion.

One of the most popular types of speed reducers is the worm and worm-gear type. This has been developed to a high state of perfection, so that the prevalent conception that a worm drive is inefficient has been entirely exploded.

The efficiency of such a drive is entirely dependent on the helix angle of the worm. The greater the angle (up to about 42 deg.) the greater the efficiency and, vice versa, the smaller the angle, the greater the power loss. This fact was not generally recognized in the early days by the industry, and accounts for the disrepute into which the worm drive fell.

Fig. 1—This shows an auxiliary pinion shaft connected to a worm gear speed reducer in a cement plant.

The first reduction in speed is made by the worm gear reducer. A pinion mounted on the auxiliary shaft, which is coupled to the low-speed shaft of the reducer, drives the large gear and gives the second reduction in speed. This arrangement is often used to obtain greater speed reductions than can be efficiently secured by the use of the speed reducer alone. Note that the pinion shaft is supported in its own bearings.



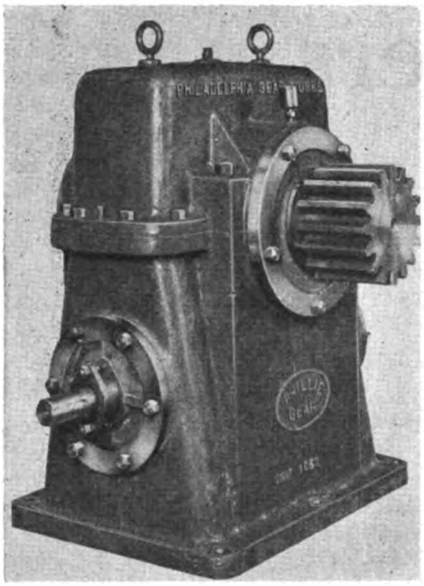


Fig. 2—Here is a worm speed reducer with a pinion on the low-speed shaft, making unnecessary the use of an auxiliary pinion shaft.

A pinion should not be mounted on the low-speed shaft of a speed reducer unless the bearings have been designed for this service.

Generally, all manufacturers of this type of drive strive to use as steep a helix angle as possible in their drives. However, in case this is not done, principally for economic reasons, such as the cost of providing new cutting tools, and so forth, a somewhat less efficient drive is the result. To cover up this defect, an extremely large and heavy casing may be provided for the drive so that the wasted power, manifesting itself in heat can be easily dissipated into the surrounding air.

Although it is possible to obtain extremely large reductions with this type of drive the power loss in the higher reductions precludes their economical application. Ratios of 60 or 70 to 1 are common, but beyond that point the efficiency drops very rapidly. To obtain higher reductions and still retain the right-angle feature of these drives two expedients may be used. The first and more common one is to provide an anxiliary shaft supported on its own bearings as shown in Fig. 1, upon which a pinion driving a gear is mounted. This shaft must be suitably connected to the final shaft of the speed reducer. Another more recent method is to employ a speed reducer especially designed with suitable bearings as in Fig. 2, to permit the mounting of a pinion directly on the slow-speed shaft. In any case, the manufacturer of the speed reducer should be informed of the conditions under which his equipment must operate as his experience has taught him what may and what may not be done with a successful drive.

A manufacturer of this type of equipment also has a good many requests for a worm drive which is to be self-locking; that is, it will not allow the load to run back when the power is shut off. There is nothing exceptionally difficult about this and a machine is made to conform to the user's specification. However, when the machine is put into service the manufacturer usually receives frantic telephone appeals to save the machine from burning up. The heating that is causing so much concern is due to the fact that a self-locking worm is inherently inefficient and at least 50 per cent of the power input is wasted in heat. As the reducer has only a limited amount of radiating surface the temperature rises to a critical point in a very short time. At this high temperature the viscosity of the lubricating oil is broken down; consequently metal-to-metal contact takes place between the worm and gear.

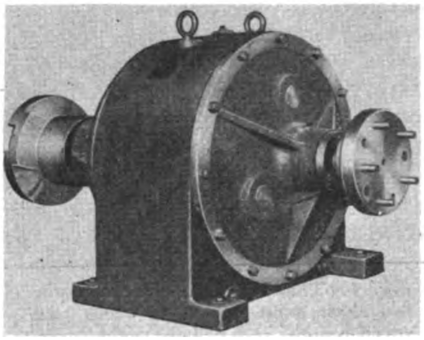


Fig. 3—Spur-gear reducer with flexible coupling connection.

This is a planetary type of speed reducer, which type has the advantage of giving the largest reduction possible in a small amount of space.

Before this point is reached let us hope that the drive is shut down; otherwise the consequences will be distressing and costly.

The remedy for this heating is to run the worm at a slow enough speed to allow the casing to dissipate the heat to the surrounding air, or to water-cool the drive. The latter expedient is, of course, a rather unsatisfactory solution. When a continuous direction of rotation is desired and it is merely necessary to hold the load in case of failure of the power, a more successful expedient is to employ what is commonly known as a backstop. This effectively prevents any backward movement of the load, in fact limiting the backward movement to the actual backlash in the gears. This feature was especially developed for grain elevator use and has proven very effective in service.

Likewise, the user should not expect a worm drive to operate without oil. The oil best suited for its use is specified by the speed reducer manufacturer and the maximum of service and economy can be expected only by its use. Very often it is assumed by the purchaser that the reducer has been shipped with the proper amount of oil in it. This is impracticable for obvious reasons. An aggravated instance of this came to the writer's attention some years ago, when a speed reducer was placed in operation not only without oil, but in addition was located next to a furnace where the surrounding temperature was in the neighborhood of 300 deg. F. Under these conditions the drive was worn out at the end of a week. Of course, the gear manufacturer was to blame!

Another design of speed reducer having peculiarities of its own is the spur-gear type, which is readily classified into two distinct groups; the planetary and the non-planetary type. Both types have certain advantages.

The non-planetary type usually consists of spur gears radially disposed about a central pinion. Each of the spur gears is keyed directly to pinions which in turn mesh with a central gear mounted upon the slow-speed shaft. This arrangement has the advantage of giving comparatively low reductions and keeping the rotational speeds at a minimum.

On the other hand, the planetary type, shown in Fig. 3, has the advantage of giving the largest reduc-

Fig. 4—Single-reduction type herringbone speed reducer.

Owing to the fact that the high-and low-speed shafts are offset, but parallel, this type of reducer requires more floor space than any of the other types described in the text, although it has the advantage of being well adapted to high-speed operation. Two units are shown here. The cover has been removed from one unit to show the herringbone gears.

tion possible in the space available, and consists of spur gears or idlers radially disposed about a central pinion and in turn meshing with a stationary internal gear. The so-called idlers must, of course, revolve on their own axis, but in addition must be free to climb around the internal gear. To that end they are mounted upon studs which are rigidly fastened to a spider mounted upon the slow-speed shaft.

There is also another type of non-planetary drive employing all of the planetary components, but the internal gear which is keyed to the slow-speed shaft, is allowed to revolve instead of the idler gear assembly as a whole. This type of drive gives a reduction intermediate between the non-planetary type mentioned and the planetary.

Planetary spur-gear reducers of the single-reduction type now available on the market are quite satisfactory for ratios between 4 and 8 to 1. When the 8 to 1 ratio is exceeded, they become rather large in diameter. Again, when the ratio is reduced below approximately 4 to 1, the speed at which the idler assembly revolves within the internal gear becomes excessive, causing needless agitation of the oil in the casing with consequent heating and power loss.

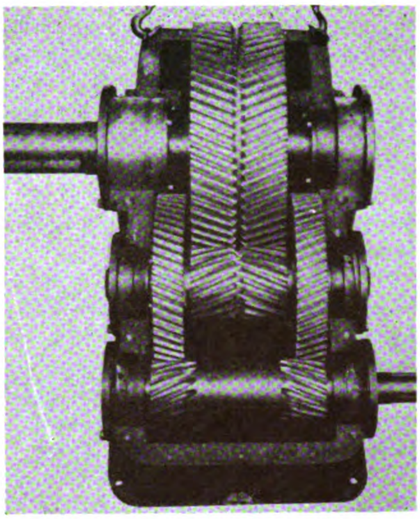


Fig. 5—This is a double-reduction type herringbone gear speed reducer.
The set of gears providing the first reduction is split and consists essentially of two sets of helical gears one of which is cut with a right-hand, and the other with a left-hand, helix.

The revolving internal-gear type (single reduction only) is best suited for ratios between 3 to 1 and approximately 7 to 1. The same limitations apply to this type as to the planetary type.

Referring again to the non-planetary type which does not employ the internal gear, this is admirably suited for smaller ratios, generally up to approximately 6 to 1 in the so-called single type. However, the single-reduction gear in this design is really a double-reduction gear. Very small ratios are possible, even a 1 to 1 ratio being obtainable, which is entirely impossible with any of the types previously mentioned.

It will be noticed, however, that the foregoing remarks have all been made about the single-reduction type. Where higher ratios are required it is, of course, necessary to "double up" the reduction; so, two drives are coupled in series in the same casing.

By making a simple calculation, it becomes obvious that ratios below about 12 to 1 are difficult to obtain in the double planetary design; hence, it is usual to couple a 4 to 1 and a 3 to 1 together to obtain this ratio. Thus, quite a perceptible gap exists between the maximum ratio of 8 to 1, obtainable in the single type, and the minimum of 12 to 1, obtainable in the double type.

The same remarks apply to the revolving internal-gear type with, of course, the limits changed somewhat; that is, the lower limit of the double type of this design is somewhere around 10 to 1.

None of these limitations apply to the non-internal, non-planetary drive, although for the larger ratios the drive as a whole becomes extremely long.

It may be said, in general, that the one outstanding feature of all of these different types is that all unbalanced forces are neutralized, leaving nothing but a rotary motion. The greatest characteristic of these drives is that both the slow-speed and high-speed shafts are in a straight line which is an important advantage in a great number of instances. These different types are, when properly designed and constructed, very satisfactory, as shown by the very large number now in successful operation.

It may be pointed out, however, that the mounting of pulleys, sprockets or pinions upon either of the projecting shafts, without the provision of an outboard bearing seriously affects the alignment of the gears inside of the casing, with resulting injury to the gears and eventual failure of the unit.

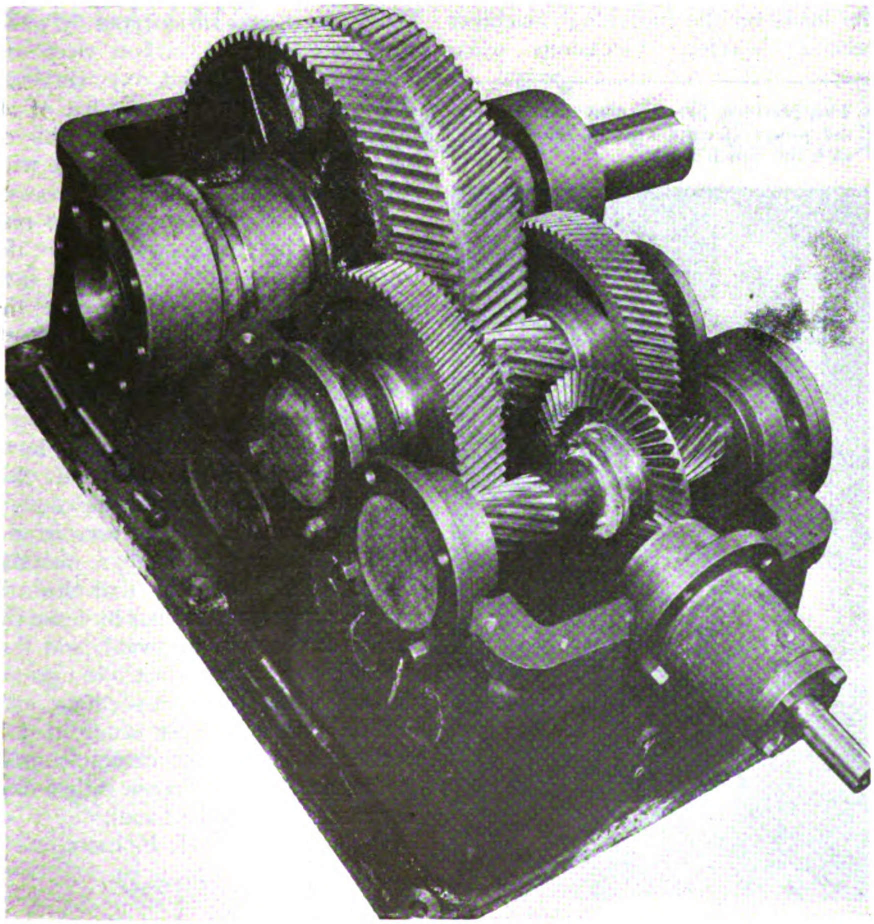


Fig. 6—Combination spiral bevel and double herringbone gear speed reducer.
This type of speed reducer may be used where a right-angle drive is necessary. The spiral bevel gears provide the first reduction in speed. The next reduction is obtained through the two sets of helical gears, and the third through the herringbone gears.

The statements made above regarding the lubrication of worm-gear reducers apply also to the spur-gear type.

Until a few years ago, the worm and spur-gear types of reduction units held undisputed sway. This popularity is being shared by the herringbone type of drive, which is highly efficient as well as silent in operation. It lends itself especially to the transmission of large amounts of power, although it is rapidly coming into its own for the intermediate and lower horsepowers in spite of its comparatively high cost.

The herringbone type of speed reducer does not possess the right-angle feature of a worm drive, nor "the shafts in line" feature of the spur-gear drive. Its high- and low-speed shafts are offset, although they are parallel with each other. Thus, it will be seen from Fig. 4, that a herringbone drive requires more floor space than any of the other types.

The single reduction type, consisting of one pinion and one gear—is commonly manufactured up to a ratio of about 7 or 8 to 1. In ratios over this, it is usual to obtain the required reduction in two steps. There are two distinct types of the double-reduction unit now available. One type consists of two sets of herringbone gears arranged in series. In the other type, Fig. 5, the first set of gears is split; that is, the first drive really consists of two sets of helical gears, one set being cut one hand, and the other being cut the opposite hand. They are mounted far enough apart to allow the insertion of the final drive pinion between the helical gears. This form of construction equalizes the loads on all bearings as well as making a more compact drive which is not the case with the first-mentioned type. These two types are commonly manufactured in ratios up to about 60 to 1. Greater ratios are more economically secured by the triple-reduction type.

A recent modification of the herringbone reducer which allows it to displace successfully the worm drive involves the use of a spiral bevel gear for the first reduction. A unit of this type is shown in Fig. 6. The spiral-bevel gear (the only true spiral gear) has been brought to a high state of perfection largely through its use in the automotive field; its use in connection with the herringbone unit makes this type of drive available where a right-angle drive is imperative.

The herringbone gear reducer is susceptible to the same influences as the other types of reduction units. Flexible couplings should be used as much as possible. Outboard bearings should be provided for any overhung loads. Lubrication recommendations should be carried out to the letter and, lastly, any unusual conditions should be brought immediately to the manufacturer's attention.

The foregoing discussion refers to the numerous standard drives now being manufactured by various companies, and should not be construed as applying to special types of drives which are manufactured for particular installations.

Substituting Suspended Platform for the Shop Ladder

IN ONE of the earlier factories built without its own power plant, the power and lighting circuits from the transformer on the street were brought through the wall near the ceiling where the meters, switches, and fuse boxes were mounted.

At first, there were but one power and two lighting circuits running from the board, but as the load increased, four power and eight lighting circuits were required.

The practice of under-fusing the lines resulted in an increasing number of delays to renew the fuses, as the loads on the individual machines became heavier. Occasions arose also, when meters had to be changed or tested and additional circuits had to be added. In order to reach the equipment installed at this location, it was necessary to interrupt the work at the bench. When meters had to be tested or new circuits installed, a temporary platform was constructed, but for ordinary repairs, such as renewing fuses, the shop ladder was used.

This platform permits men to work on the power circuits without interfering with the bench work.

The inconvenience and the risk of using ladders at such times influenced the foreman to install the platform shown in the accompanying illustration. The cost was slightly more than that of the six boards and the white paint used to make it harmonize with the plant interior.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Comment on "The Selection of a Welding Process"

AN ABSTRACT of a paper "The Selection of a Welding Process" by L. E. Everett of the Nugent Steel Castings Co., Chicago, Ill., appeared on page 313 of the July issue of INDUSTRIAL ENGINEER, in which the application of three welding processes to his work was discussed.

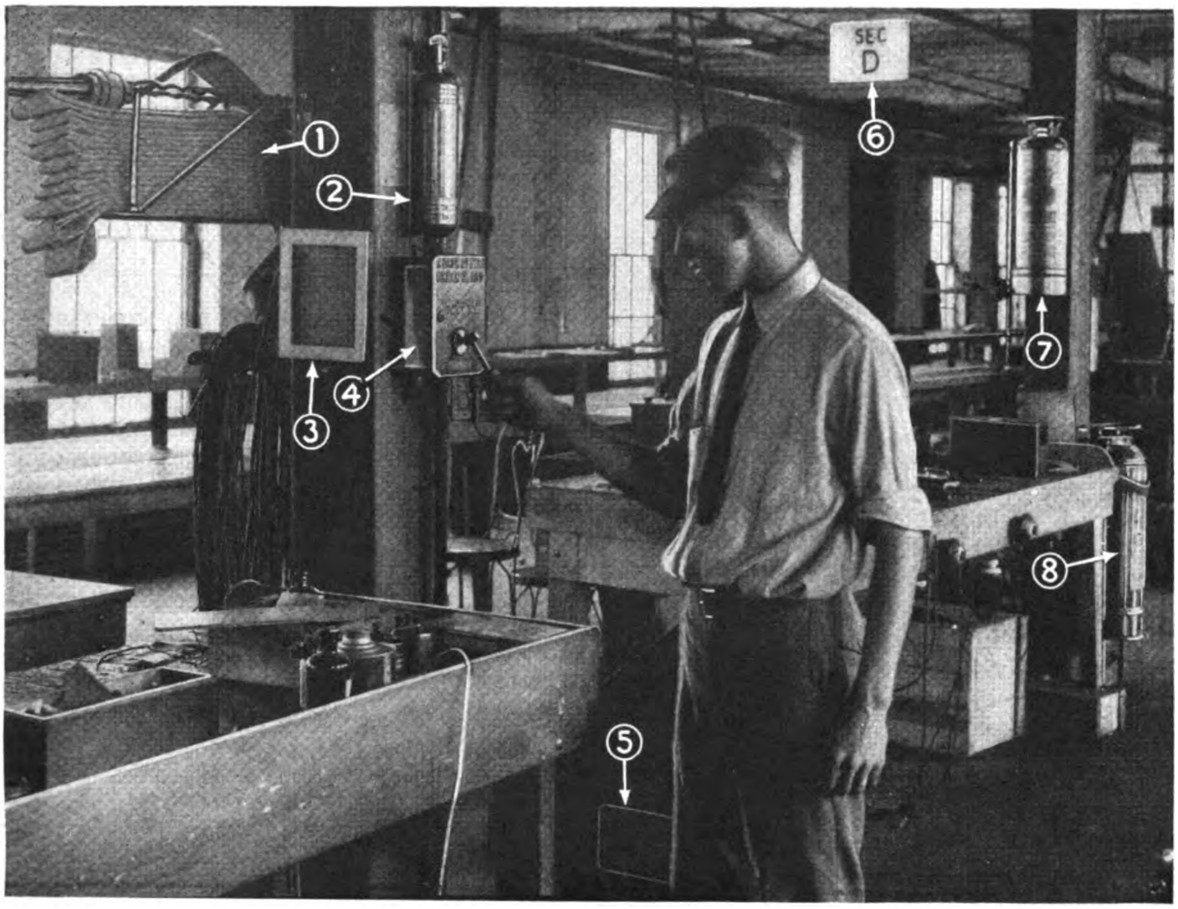
It was stated in this article that Mr. Everett uses three types of welding processes—the carbon electrode, metallic electrode, and oxy-acetylene. There is no reason for the use of all three of these processes, for all of the work, in general, can be done with either the electric or the gas process.

There is one reason, and one reason only, for using welding in the work described, and that is to save money. With proper technique the electric process will do all the work that the other process will do and, in general, that fact is being fully recognized.

There is one statement made, however, which should be corrected: that is, that the carbon electrode process increases the carbon content in the weld. This is positively a mistake. There is only one way that the carbon electrode process can increase the carbon content in the weld, and that is to dip the carbon electrode into the molten metal. With proper manipulation this should never occur, and if it does not occur the carbon content in the metal will decrease rather than increase in the weld metal.

J. F. LINCOLN.

Vice President,
The Lincoln Electric Company,
Cleveland, Ohio.



Breaking the glass turns in an alarm. Fire protection equipment shown here includes: (1) Fire hose. (2) Pyrene carbon tetrachloride, 1-qt. size. (3) List of alarm stations. (4) Break-glass-front Auto-call alarm station. (5) Self-closing waste can. (6) Section marker. (7) 2½-gal. Foamite extinguisher. (8) 5-gal. Foamite extinguisher.

Providing Fire Protection *for an industrial plant*

By AL ANSELM

General Superintendent
Fansteel Products Co., Inc.
North Chicago, Ill.

INDUSTRIAL fire protection problems result from the hazards presented by the type of building, construction, the contents, or the processes employed. Modern buildings and many processes offer practically no fire hazard in themselves. The contents in practically all types of industrial works are burnable, sometimes highly inflammable, and cause a hazard even in the so-called fireproof building because a serious fire in the contents will damage the building.

Our plant, in contrast to many others, offers a triple hazard in that several of the buildings are old and of mill-type construction. The processes in several departments involve reductions under high temperatures or the use of highly inflammable materials, and the product, especially when packed, is highly inflammable. In addition to this, our plant is located in a comparatively small town, and even though there is a good local fire department, for a town of its size, this fire department would be handicapped in fighting a big fire in an industrial plant.

Our plant is engaged in the reduction of rare or special metals, such as tantalum, tungsten and molybdenum; in the case of tantalum very high temperatures are required for reduction, whereas reduction of the other two metals involves the use of large quantities of hydrogen gas. Tantalum is used in all Balkite radio and industrial chargers, as well as in the B battery eliminators. Pure tungsten is used for distributor points in automobile ignition systems, and molybdenum for various applications, including grid wire, in radio vacuum tubes.

The plant consists of 16 buildings containing about 120,000 sq.ft. of floor space. One of these buildings is four stories high, two buildings are three stories high, three buildings are two stories high, and ten buildings are single story. Only two of these, the office and building No. 3, are of modern, concrete fireproof construction; the others are of the pressed-steel, portable-building type, or of mill-type construction with brick walls. Some of the latter buildings are quite old.

With all of these hazardous conditions our only safe protection against

fire is to provide facilities to put out any fire before it has had an opportunity to get a real start. This is the basis of all of our protection at this plant. As a result, we have organized our fire protection activities along the following lines:

(1) An ample number of portable hand extinguishers are placed convenient to all serious hazards, and a smaller number in all other locations, even though less hazardous. These extinguishers are supplemented by three 40-gal. chemical carts and a wet and dry-pipe sprinkler system.

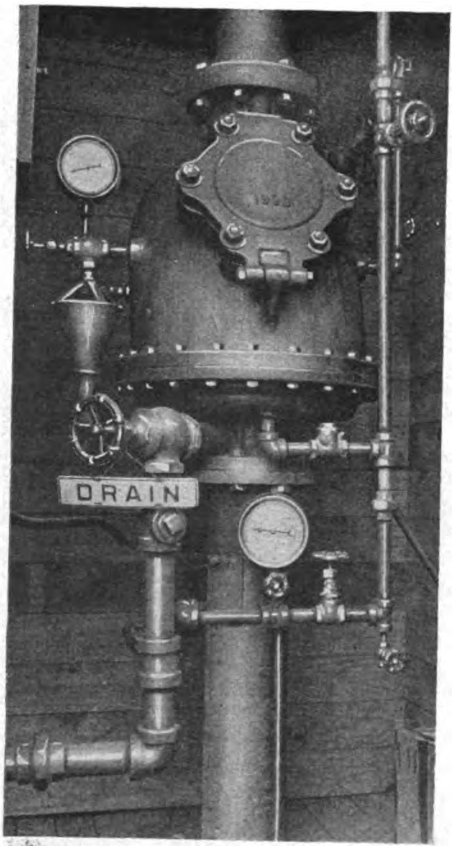
(2) A fire department recruited from the plant personnel whose training is supplemented with fire drills.

(3) Well-trained night watchmen who are organized into a fire department for night fire protection.

(4) An alarm system so arranged that a fire alarm may be turned in from practically any point in the plant and at the same time signal the local city fire department.

Perhaps the first comment a stranger would make on coming into some of our departments would be in regard to what might seem to be a surplus of portable extinguishers. In the departments where the greatest hazards are present a portable 2½-gal. or 5-gal. Foamite-Childs extinguisher filled with Foamite is placed on each floor at each column down the center of a fairly narrow building. The 2½-gal. extinguishers are hung from the columns and the 5-gal. extinguishers are set a few inches above the floor, alongside the column. This provides an extinguisher about every 15 ft. in a building approximately 220 ft. long.

In addition, two hand carts with 40-gal. tanks, also filled with Foamite, are placed in this same building—one on the first floor and the other on the second. These carts are moved to the most active floor in case production in some departments is reduced, but are never taken from this building. The special hazards in this building are due to the molten compound used for insulating coils and for sealing the Balkite trickle chargers.



Dry valve on dry-pipe sprinkler system.

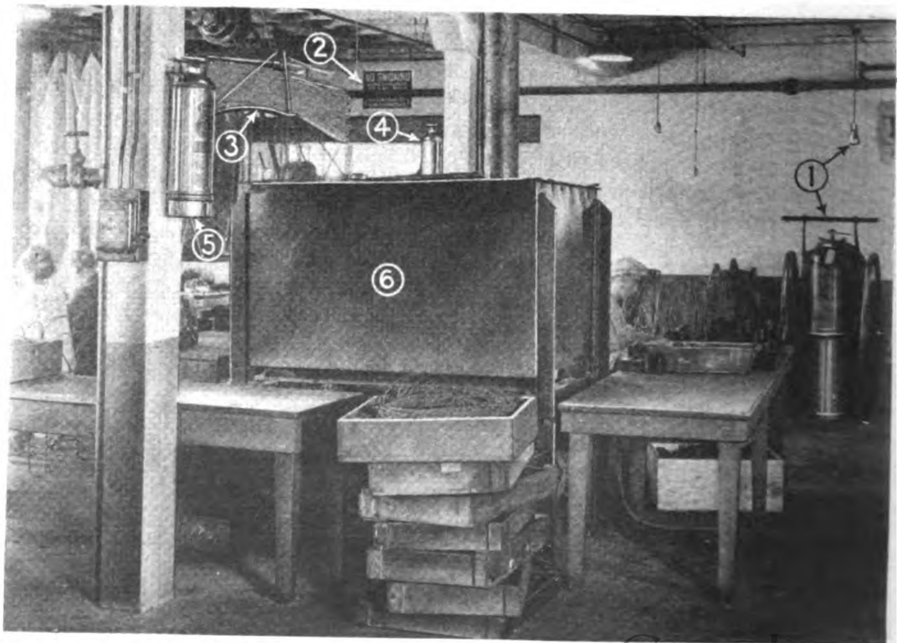
In buildings which are difficult to heat, such as the warehouse in this plant, dry-pipe Rockwood sprinklers are used. Air pressure in the sprinkler lines balances the water pressure against a diaphragm in this valve. When a sprinkler head opens the air pressure is released, whereupon the water breaks the diaphragm and fills the sprinkler lines. Two electric strip heaters are fastened to the water side of the pipe to keep it from freezing.

A red light burns continuously at all exits and also just above the three 40-gal. Foamite carts. These red lights are on a separate circuit leading directly from the main distribution switchboard on the incoming lines from the transformers. Because they are not connected into the local lighting cabinets they cannot be turned off accidentally. Also, they are not affected by fuse failures on the regular lighting circuits.

We selected Foamite protection here because of its smothering action on oil, pitch or wax fires. Altogether, this building contains 36 2½-gal. and 6 5-gal. Foamite extinguishers, 20 1-qt. Pyrene carbon tetrachloride, and 4 soda-acid extinguishers and the 2 40-gal. Foamite carts. In addition, the building is provided with a Rockwood sprinkler system, which is illustrated and described on this page.

Dry-pipe sprinklers are used in some of the buildings because of the danger of freezing during cold weather. As stated, some of these are old buildings and difficult to keep warm. Two electric strip heaters are fastened on the side of the pipe just below the valve for use in extremely cold weather.

Practically 90 per cent of the plant is provided with Rockwood sprinklers. However, one old building which is isolated from the others is not provided with sprinklers. Fyr-Fyter carbon tetrachloride extinguishers of 2-gal. capacity are placed in the warehouse and other locations using the dry-pipe sprinklers where the chemical in the extinguisher is exposed to low temperatures. Carbon tetrachloride does not freeze until about 40 deg. F. or more below zero, whereas some other chemical extinguishers



Fire protection equipment in one of the more hazardous locations.

This is one of the floors on which baking ovens and vats of molten compounds create a serious hazard in a mill-type building. A red light burns continuously above the 40-gal. Foamite cart (1) which is never taken from this floor. The "No Smoking" rule (2) is strictly enforced. Fire hose (3) is mounted on the column. A 2½-gal. Foamite extinguisher (4) and (5) is mounted on each column. Foamite is used in extinguishers because of the smothering action of the Fire-Foam on wax and oil fires.

that have water solutions will freeze at temperatures above zero.

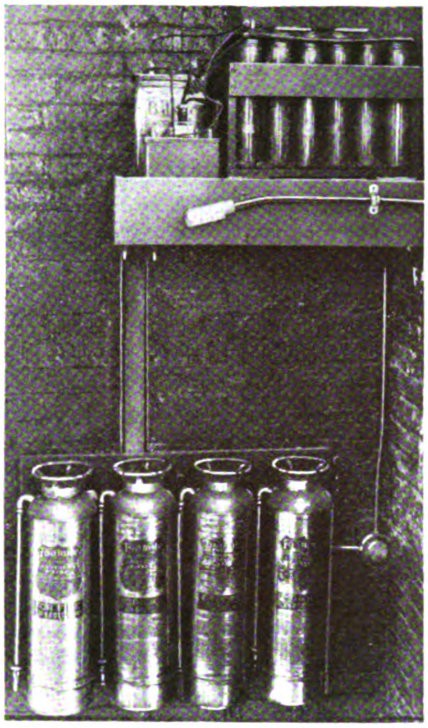
Electrical fire hazards also require the use of carbon tetrachloride extinguishers because the chemical is a non-conductor and can be directed upon live circuits without any serious consequences. Therefore, a 1-qt. Pyrene carbon tetrachloride extinguisher is placed at each electric furnace, at the electric heaters for melting the insulating compound, and near other electrical hazards. In addition, a number of ½-gal. Fyr-Fyter carbon tetrachloride extinguishers are placed at other parts of the plant.

As stated, the two 40-gal. carts are not removed from this extra-hazardous building. Another 40-gal. cart is kept in the boiler room, which is centrally located, and is used by the fire department when reporting to any alarm.

Each fire extinguisher carries a tag showing when it was refilled last, and after an extinguisher is used it is placed on the floor instead of being hung back in position. However, the fire chief in his weekly inspection looks for empty or partially filled extinguishers by actually lifting and shaking each. All extinguishers are emptied and refilled once a year. All fire hose is tested once each year and defective hose replaced. Special gum-rubber-covered hose is used in departments where it is exposed to acid fumes.

For some time we were bothered by men using the carbon tetrachloride taken from an extinguisher for cleaning their hands or removing spots from their clothes. As a result, we frequently found a number of these extinguishers empty or partially empty, but still in position. This difficulty has been overcome by the addition of some red oil dye to the tetrachloride. Since then we have had no trouble from this source.

The plant fire department consists of eight men, including the chief, during the day shift, and a similar number of watchmen who also serve as firemen at night, under the direction of a chief watchman. The day fire department is composed of the yard foreman, who acts as chief, the steamfitter, the electrician, two men from the machine shop, and three others from various departments.



The alarm circuit requires a reliable source of power.

The storage battery, which is charged by a Balkite trickle charger, is used to sound the trouble bell through the dual control board so that even though all outside sources of power are cut off an alarm will sound. The members of the fire department who are in this building take with them one of the extinguishers shown here, when they respond to an alarm.

The first three of these are men who are thoroughly acquainted with every part of the plant because their work carries them into all departments. Also, the electrician is available to cut off the power on any line, if necessary. The other members of the force are selected from men who can leave their work without any serious interference or loss as soon as the alarm is sounded. Primarily, they must be men who can think clearly and are not easily excited.

Fire drills are held twice a month, for which the men receive $25 a year in semi-annual payments (January and July) as a reward for this extra work.

When an alarm is sounded these men report to the boiler room. They then take the 40-gal. Foamite cart, axes, and other equipment to the part of the plant where the alarm was turned in. The code number of the alarm indicates the location. The eight night watchmen are drilled similarly and report after every night alarm in the same way.

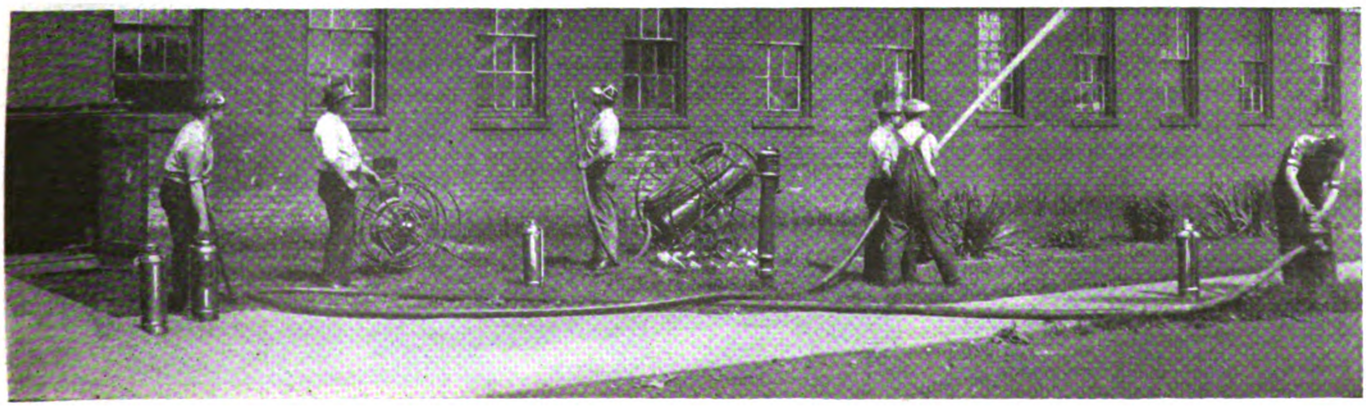
During the day when the plant is operating, a fire could gain but little headway before being discovered and attacked with an extinguisher, or an alarm sounded. Ordinarily, a fire at night has a much better opportunity to gain headway. We endeavor, however, to give a night fire as little chance as possible to grow by having frequent inspections made by the watchmen.

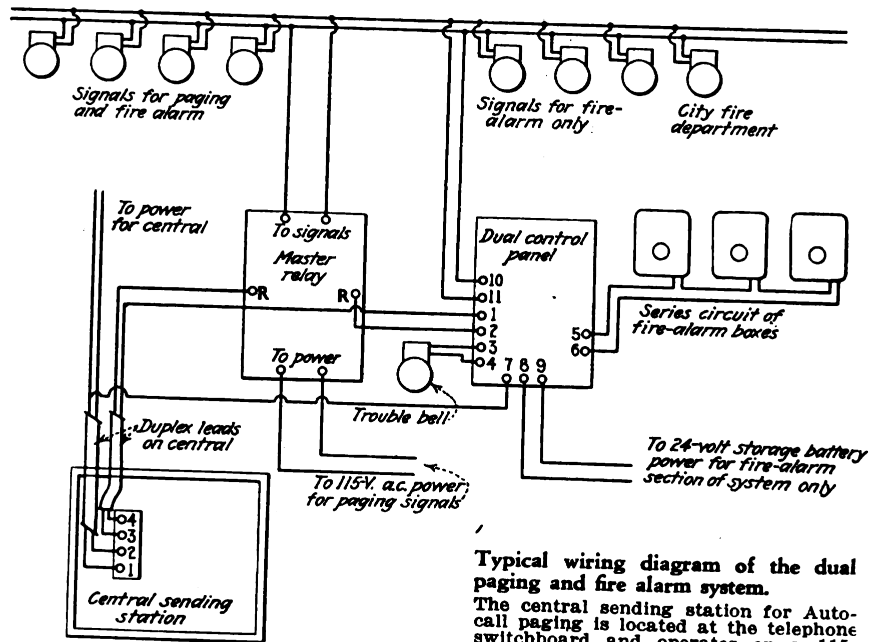
For example, in the most hazardous building, one watchman devotes his entire time to making two complete rounds per hour. His trips are begun on the hour and on the half-hour. In addition, one of the other watchmen, who also looks after another building, follows him up, beginning on the quarter after and ending at a quarter to, the hour; a third watchman begins his rounds in this building at a quarter to the hour and ends at the quarter after. As a result, every point in this building is inspected every 15 min. by one of three men.

Of course, if a fire had a 15-min.

The company fire department in action.

When an alarm is sounded, the men seize a 2½-gal. extinguisher and report to the boiler room to get this 40-gal. Foamite cart. The hose cart is stationed in the small shed at the left where it is convenient to the hydrant.





Typical wiring diagram of the dual paging and fire alarm system.
The central sending station for Autocall paging is located at the telephone switchboard and operates on a 115-volt a.c. circuit. An alarm is sent in by breaking the glass front in one of the fire alarm boxes. The dual control panel cuts out any paging calls which might be sounding and turns in a fire alarm on the paging-signal system, the trouble bell, and the special "fire only" alarms, one of which is located at the city fire department. If the alternating current power should fail the trouble bell and the "fire only" signals, which are on the storage battery circuit, would still be sounded.

start it would probably be beyond control. However, it is not very likely that a fire could start without there being some indication more than 15 min. before flames burst out. Also, if one watchman should fail to detect an incipient fire, one of the other two watchmen would be likely to discover it. Every other building in the plant is covered by watchmen, but not so frequently as this.

The watchmen carry Hardinge portable clocks which are punched by keys located at each of the 30 watch stations. Each of these keys carries a different letter, symbol, or number which is printed on a tape in the clock, indicating the station and the time. Arranging the numbers in sequence, or having the letters spell a word indicates at once whether the watchman has made his rounds in the proper order. An extra long space between letters or symbols indicates that too long a time has elapsed between visits to stations.

The watch stations are located so that the watchman must pass the full length of every room or floor to get from the station in one end to the station in the other. In addition, stations are placed at some of the more hazardous locations so that the watchman must at least stop there.

This entire protective system is tied in with the coded alarm system which may be turned in from any one of the 26 fire alarm stations about the plant. These stations are placed where they are easy to find, particularly by the night watchmen, but they are in no way connected to the watch stations.

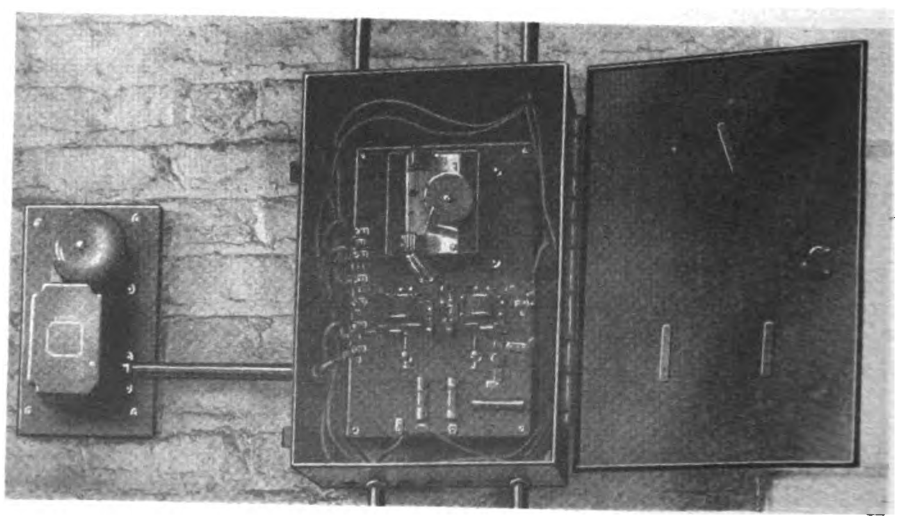
Coded alarm signals are transmitted through an Autocall paging system which is used to call or page from the telephone switchboard, by means of a coded number, any individual or executive when he is out in the plant or away from his regular location. It is possible by connecting devices approved by the Underwriters' Laboratory to use this circuit for the delivery of coded fire alarms.

Alarms are turned in at any of these 26 stations by breaking the glass in the Autocall fire alarm box, as is shown in the illustration on page 405. These fire alarm boxes are wired in series on a circuit of No. 10 rubber-covered copper wire in conduit. The type of circuit used is shown in the accompanying drawing.

When put in operation, these boxes transmit, through the dual control board, a distinctive coded alarm for fire throughout the plant on the regular Autocall paging circuit. Each alarm station has its number and the members of the fire department are supposed to know the location of the box corresponding to each number. However, a list of these stations is placed at each box and in the boiler room where all firemen report so that they can check the location, if necessary.

With this installation both the fire alarm box circuit and the fire alarm signal or bell circuit are constantly under automatic supervision so that there is an immediate indication when anything goes wrong. This is given by means of a bell located adjacent to the dual control board and shown in the illustration on this page. The circuit is normally closed; therefore if impaired for any reason the trouble bell will ring continuously. Without automatic supervision such as this the system might get out of order and fail to operate in an emergency.

The dual control board mentioned above is supplied with binding posts for a "fire only" circuit. From this point on the dual control board is installed a circuit of bells which will operate only from a fire alarm box. This means that in addition to the fire alarm sounding throughout the plant on the paging circuits there are a number of signals sounding the same alarm, which are silent at all times



The heart of the fire alarm system.
By means of this dual control panel the Autocall paging system is connected into the fire alarm box circuits and the "fire only" circuits so that the paging circuit is cut out when an alarm is sounded. The trouble bell at the left signals all fire alarms and also any interruptions or trouble on the fire alarm box or "fire only" lines.

except on the operation of a fire-alarm box.

These special alarm bells, which consist of large gongs, are not used in the paging circuit but are located at various places around the plant yard so that anyone working outside will hear them. In addition, a gong in the power house gives the signal to the engineer who repeats it on the whistle.

By means of a connection between the "fire only" terminals of this dual control board and the city of North Chicago's fire alarm circuit, all coded alarms sounded within the plant are transmitted simultaneously into the city fire department upon the operation of any fire alarm box within the plant. On a recent test of this equipment by state fire officials, the city fire department which is located ½ mile away was on the ground in less than 2 min.

Another feature of this installation is the use of what is known as an Autocall selective relay. In the past many such connections between local fire alarm and city fire alarm circuits have been made, but in recent years the privilege of making such connections has been almost universally denied because of the many false alarms turned into the city fire department through such connections.

This selective relay, which consists of an air-dashpot element, is installed between the dual control board and the city fire alarm circuit on the "fire only" circuit of the dual control board and is so arranged that a false alarm cannot be sent into the city fire department, regardless of what takes place on the local circuit. In this case the local fire circuit can be cut without transmitting impulses to the city fire circuit.

The fire alarm boxes are so arranged that upon the arrival of the company firemen in response to an alarm it is possible, by the use of a special key, for the chief to manually signal from any box codes that he might use for indicating that the fire is out, or to call additional assistance, or for any other use.

The plan of using a common circuit for paging purposes from the telephone switchboard and for the delivery of coded fire alarms naturally brings up the question of what happens in the event that this common circuit is actually in use for paging purposes when one of the fire alarm boxes is put in operation.

This contingency is taken care of because the dual control board is equipped with a time-element device which cuts out the Autocall paging device located at the telephone switchboard the instant a fire alarm box is placed in operation. This cut-out is complete and remains until four standard rounds of the fire alarm have been sounded, when the time-element device again automatically cuts in the paging device located at the telephone switchboard.

A further complication would seem to arise in the use of a common circuit in case the firemen were not able to distinguish between a coded paging call and a coded fire call. This is cared for by preceding all coded fire calls by ten rapid strokes of the signal bells, which are then followed by a slower code indicating the fire box in operation. These ten rapid strokes, followed by the slower code, are sounded four times when a fire alarm box is put in operation.

In the use of this circuit for paging purposes the paging codes are very slow in operation and no paging code, irrespective of how many men are subject to paging, ever transmits more than seven continuous impulses to the paging circuit. Therefore, ten rapid strokes on this circuit instantly spells fire to the fire organization and the following slower code designates the location of the fire.

The fire alarm box circuit and the "fire only" signal circuit are operated from a 24-volt storage battery. The Autocall paging equipment is operated from the 115-volt lighting circuit. Should the alternating-current lighting circuit power fail, the fire alarm would sound on the "fire only" circuit and through the dual control board to the city fire circuit. The 12-cell storage battery we use to supply power to the fire circuit is kept charged by means of a Balkite-type trickle charger which is constantly in the circuit.

With all our hazards it seemed at first as though adequate protection and safeguarding against fire were impossible. However, by providing an ample number of extinguishers and training both day and night men to operate them, and also by installing a signal system to sound the alarm and call the men to the fire as soon as possible, we have decreased the hazard sufficiently to obtain additional insurance at a better rate. In conclusion, I might add that real fire protection is fire prevention; in other words, "Don't give fire a chance."

Recommended Practices in Installing and Testing Grounds

FROM an analysis of the information obtained by the National Electric Light Association, and reported in publication No. 267-63, no doubt is left of the opinion held by the majority of engineers of the value of inspection work in transformers and their grounds, not only from the viewpoint of continuity of service, but its economic value as well.

It is suggested that in those sections where the ground conditions are not good, enough tests be made to decide whether ground testing and soil treatment are desirable or not.

In general, the ground rods should be located as near as possible to the apparatus to be protected, but where a dry, high-resistance soil is encountered nearby and a better location can be obtained, 100, 200 or even 300 ft. away, it should be utilized in preference to the less favorable location close at hand. In this case at least one pipe should be driven as close as possible to the apparatus to be protected regardless of soil conditions, and as many more pipes driven farther away as are necessary to bring the total ground resistance down to the required value. This value should not be greater than 15 ohms.

In no case should less than two pipes be driven. It will not be found advantageous to drive more than six or eight pipes in any one group. When this number does not bring the ground resistance to less than 15 ohms, another group should then be driven not closer than 15 or 20 ft. to the first group. No individual pipes should be located closer together than 6 ft., except where it is impossible to obtain this clearance.

In places where a pipe projecting above the ground would be objectionable, it should be cut off 6 in. below the ground level and the soldered joint painted with tar. Avoid making any joints underground wherever possible, and none are allowable in the wire unless it is absolutely impossible to prevent them—then they should be coated with tar.

All ground pipes should be tested for resistance at the time of instal-

lation and periodically, as determined by future tests.

For this purpose a transformer (used to supply an ungrounded source of energy), two resistance units of 20 ohms each and voltmeter will be used, the connections of which are shown in the accompanying illustrations.

As it is necessary to drive two or more pipes, it is necessary to secure the individual resistance, and then since the pipes are connected in multiple, the combined resistance of the pipes will be the reciprocal of the sum of the reciprocals. The algebraic solution for individual resistance will be fairly accurate only when all the pipes are identical, equally spaced not less than 6 ft. apart, and soil conditions are uniform for all pipes.

The apparatus to be used in testing will consist of one ammeter, 5 to 10 amp. range; one ammeter, 1 to 2 amp. range; one voltmeter, 150-volt range; one 15-ohm resistance with short-circuiting switch; two 6-ft. ground stakes, and the necessary test leads.

Readings of voltage and current are to be taken in accordance with the methods to be outlined and in the order given. If measurements indicate that the resistance of the ground under test is greater than 250 ohms, it will be necessary to reduce this value by treating the soil in the following manner:

Dig a basin approximately 2 ft. in radius and 1 ft. deep, surrounding the ground stake. Place a minimum of 60 lb. of coarse rock salt in this basin and flood the hole with water until the surrounding earth is well saturated. Back-fill the basin with the soil previously removed and add water until the back-fill is also well saturated.

A second resistance test should be made the following day.

Fig. 1 shows the method to be used in locations where the secondary neutral is solidly grounded to the water system. When testing grounds by this method, a 15-ohm resistance which is provided with a short-circuiting switch and an ammeter are connected in series with the live side of the secondary main and the ground to be tested. A voltmeter is connected between the point at which the resistance and the ammeter are joined and the secondary neutral. In cases where the current is too small to be read on an ammeter, a voltmeter, used as a milliammeter, may be used in place of the ammeter. Inasmuch as it is usually not necessary to read volt-

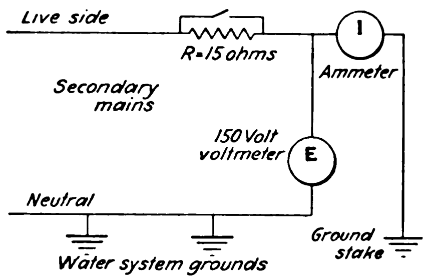


Fig. 1—Diagram of connection used to test grounds where secondary neutral is solidly grounded to water system.

age and current simultaneously, the same voltmeter may be used for both readings in this case.

The following steps should be followed when testing by this method:

(1) Start the test with the short-circuiting switch open, using the 10-amp. scale of the 5 to 10-amp. ammeter. If the reading is below 5 amp.,

(2) Connect to the 5-amp. scale. If the reading is less than 2 amp.,

(3) Close the short-circuiting switch. If the reading is less than 2 amp.,

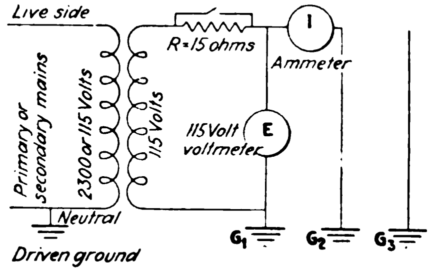
(4) Substitute the 1 to 2 amp. ammeter using the 2-amp. scale. If the reading is less than 1 amp.,

(5) Connect to the 1-amp. scale. If the reading is less than 0.2 amp.,

(6) Substitute the voltmeter for the ammeter.

It is advisable to choose a step which will give somewhere near half-scale deflection on both the voltmeter and the ammeter. When such a combination is found, take readings of the current (I) and voltage (E). If the voltage is fluctuating, these readings should be taken simultaneously, or their averages estimated. When an ammeter is used (steps 1-5), the resistance (R_g) of the ground may be calculated by dividing the voltage (E) by the indicated current (I), or $R_g = E \div I$. When the voltmeter is used as a milliammeter (step 6), the resistance (R_g) of the ground may be calculated from the following

Fig. 2—When a known ground does not exist this connection scheme should be used in testing grounds.



equation: $R_g = R_v\ (E_1 - E_2) \div E_2$, where R_v = resistance of voltmeter range used in measuring E_2. E_1 = same as E when ammeter is used. E_2 = reading when voltmeter is used as milliammeter.

At a location where a poor ground or none at all exists with which to complete the test circuit, drive two ground stakes G_1 and G_2, as indicated in Fig. 2, 4 ft. into the ground and at least 6 ft. but preferably 15 ft. apart, and use the method shown in Fig. 2 for testing. In this case, it is necessary that the source of supply be ungrounded; this may be obtained by using a 115/115-volt transformer in the existing secondary mains, or a 2,300/115-volt transformer in primary wires.

Test as described above between grounds G_1-G_2, G_1-G_3, and G_2-G_3, to obtain the resistance $R_1 + R_2$, $R_1 + R_3$, and $R_2 + R_3$, respectively. The resistance of the individual grounds will be:

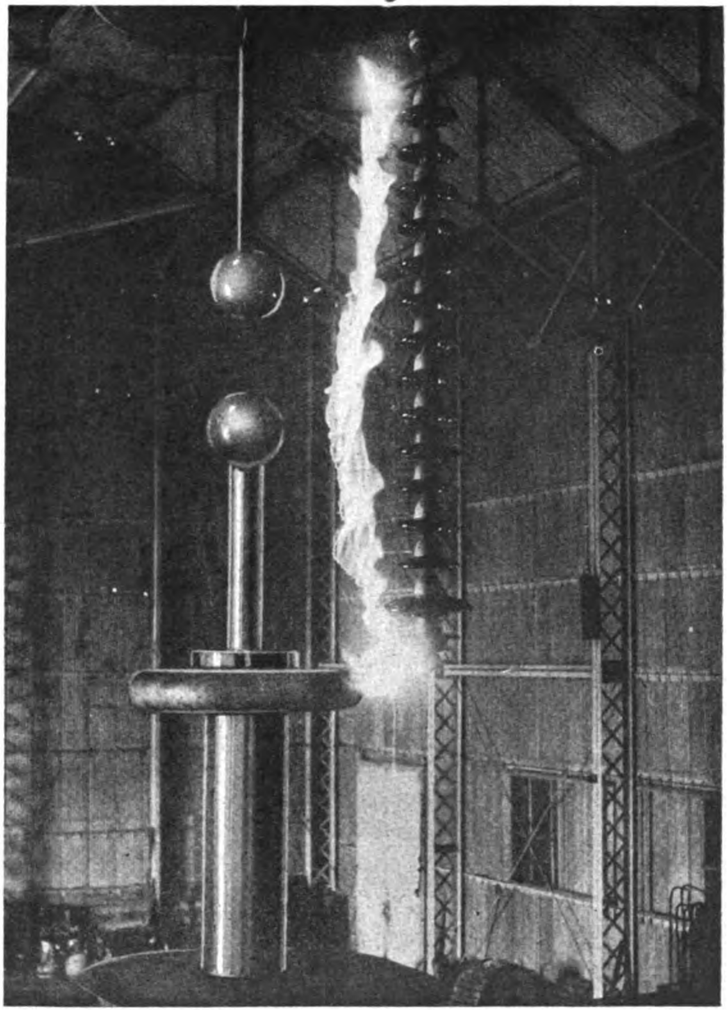
$$R_1 = [(R_1 + R_2) + (R_1 + R_3) - (R_2 + R_3)] \div 2$$
$$R_2 = [(R_1 + R_2) + (R_2 + R_3) - (R_1 + R_3)] \div 2$$
$$R_3 = [(R_1 + R_3) + (R_2 + R_3 - (R_1 + R_2)] \div 2$$

Emergency Use of Oversized Cable Clamp

THE wire cable on a hoist is only as strong as the clamp which secures the ends. The proper size of clamp, however, is designed to withstand the breaking load of the cable, when properly secured.

In several instances where accidents have occurred due to failure of the hoisting cable, examination has shown that the clamps were improperly secured, or that the clamp was of a larger size than the cable used on the hoist.

In practice, clamps are frequently found to be loose after putting a load on the hoist cable. To remedy this it is an excellent precaution to tighten the clamp with the cable under load, when the strands are taut and the cable diameter is slightly reduced. When it is necessary to use an oversized cable clamp it is advisable to put three thicknesses of cable under the clamp by doubling back the free end. It has been found that this is better than filling out the space with smooth iron or steel. It is well even with this arrangement to put the cable under strain before the bolts are finally tightened. G. A. LUERS.
Washington, D. C.



A flash 20 ft. long at 850,000 volts shows the general characteristics of the arc.

The central core is surrounded by a gas envelope which assumes different shapes and forms.

Considerations that influence design of

Arc-Rupturing Devices

By H. D. JAMES
Consulting Control Engineer, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

WHEN a contact is broken in any circuit an arc is formed, so today arc rupturing is an important function of control and it is one of the most interesting and fascinating problems in the whole range of engineering. It has been studied from many angles and a great deal of data collected, yet engineers are far from having an exact understanding of this subject, and thousands of dollars are being spent every year in developing theories and checking them by tests in order to arrive at better solutions of the different problems.

Arc rupturing is becoming of increasing importance as the power supply increases. This is most evident in the circuit breakers which are sectionalizing our great interconnected power systems. In motor control we are passing from the small isolated transformers or individual generators to systems which are capable of delivering a large amount of electrical energy through a short circuit or ground. Control apparatus which was adequate 10 years ago must be carefully considered today to determine if it is still safe to use or if additional protection, against short circuit or ground should be provided.

In thinking of arc rupturing our mind at once turns to circuit breakers, switches, fuses, magnet contactors, cam controllers, drum controllers and even the face-plate type of control. Each of these devices has its particular problem and limitations. To better understand this problem, let us consider a description of the electric arc.

When two current-carrying contacts are separated the current continues to flow by establishing an arc between the two contact surfaces. This arc is an electric conductor and consists of a stream of charged particles in the form of a tube or core surrounded by luminous gas. This gas protects the core or current-carrying part from radiation and helps it to maintain a high temperature. The gas in direct contact with the core is, of course, very hot, but as we recede from the core this gas covering gets cooler and cooler until it is no

Minimum Arcing Distances Between Contacts and Grounded Enclosures in Ventilated Cabinets

Horse-Power Rating	Distance from Contacts in Direction of Blowout		Vertical Distance Above Contacts Without Blowout				Horizontal Distance from Contacts and Distance Below Contacts	
	D.C.	A.C.	D.C.		A.C.		D.C.	A.C.
	300 Volts	600 Volts	300 Volts	600 Volts	300 Volts	600 Volts	300 Volts	600 Volts
5	1¾	3	4	Bar	1¾	3	¾	1½
10	2	4	5	Bar	2	4	¾	1½
50	3	5	6	Bar	3	5	1	2
100	4	*	*	Bar	4	*	2	3
Above 100	*	*	*	*	*	*	*	*

*Indicates barriers. All distances to be measured n inches from contact tips or arc horns. Where the walls of the enclosure are not protected by barriers or a lining of non-combustible insulating material, the arc-rupturing parts of the controller shall have the above air spaces between them and the walls of the enclosure, unless a test on any specific device demonstrates that a smaller space is safe for that particular device.

longer luminous. In observing an arc often we see the flash travel a considerable distance, but a large portion of this flash is low-temperature gas. This fact can be shown readily by attaching a piece of tissue paper to a stick and holding it in the outer part of the arc. I have seen persons who were willing to put their hands in the path of this luminous gas to demonstrate how cool it was, but I do not recommend this practice.

The arc continues to carry current as long as the central portion remains hot enough to maintain the flow of charged particles. The arc is ruptured by stretching it and cooling it. It is, therefore, important to provide a reasonable separation of the contact members in order to insure the rupturing of the arc. The longer the arc continues, the more charged particles will accumulate, and, therefore, the more difficult it is to rupture the arc. This is particularly true where the arc is inclosed between barriers. The more rapid the separation of contacts, the more efficient the rupturing device.

Atmospheric pressure has a great deal to do with arc rupturing; sometimes artificial pressure has been resorted to, but usually the arc is ruptured under natural atmospheric conditions. Everyone is familiar with the fact that the pressure decreases as the altitude increases. Some of you may have experienced difficulty in boiling potatoes at a high altitude. Owing to the low atmospheric pressure, water boils at so low a temperature that it does not develop enough heat to cook the potatoes properly. The electric arc is also influenced by this decreased pressure, as it is much easier for the charged particles to maintain the flow of current between the arcing surfaces, and much longer arcs will result. A very good illustration of the effect of altitude on control equipment was experienced by a copper company in South America at 11,000-ft. elevation. Apparatus designed for ordinary elevations was not successful and had to be changed in order to make the arc-rupturing devices effective at this high elevation.

All control apparatus should either be isolated or enclosed in order to protect persons from injury by the arc or by accidental contact with live parts. These enclosures have an effect upon the design of the arc-rupturing parts. Every time an arc is ruptured, conducting gases are developed. If this arc rupturing is repeated rapidly, as sometimes occurs in "inching service," the enclosure becomes filled with charged particles and a flashover may occur outside of the arc barriers between opposite sides of the line. Wherever possible the enclosing case should be ventilated. If a tight enclosure is necessary the arcing duty should be reduced to a minimum.

Several years ago the control manufacturers co-operated with the Underwriters' Laboratories in establishing the minimum arcing distances between contacts and grounded enclosures in ventilated cabinets. These distances are given in the accompanying table. Where it is necessary to use shorter distances, barriers should be provided or the inside of the enclosure should be lined with insulating material. As previously pointed out, the gases surrounding the arc on the outer edge are cool, so that often a thin sheet of asbestos attached to the inside of the enclosure will afford satisfactory protection. Experience is necessary, however, to know what degree of protection is required in each particular design, but if there is any doubt it is better to provide too much protection than risk burning up the controller.

Arcing contacts are usually separated from those of opposite potential and also from grounded parts by barriers. A great deal of study and experiment is often necessary to get the best results from these barriers. It is surprising how the charged particles will penetrate very small cracks. At first no trouble will result, but the gradual deterioration of the insulation surface due to these charged particles will ultimately cause a breakdown which may so badly burn the switch that it is hard to tell where the trouble originated.

It is difficult to find a material for arc barriers which has all of the desired characteristics. It must, of course, be fireproof. This means that it will be more or less hygroscopic and may absorb moisture when not heated by the arc. This moisture reduces its insulation properties and is particularly objectionable from the standpoint of surface creepage. Many otherwise good materials when subjected to arcing, deposit a conducting slag on their surface. This slag comes from the binder used for building up the material which is boiled out by the high temperature of the arc and combines with copper or copper oxide from the contacts. Generally, it is a better conductor when hot. When this slag forms it should be scraped off from time to time. Some materials close to the contacts burn away very quickly and must be frequently renewed. The research departments of large companies are continually working on this problem and are improving the materials available for arc barriers.

Severe conditions may not exist in a particular design so that an ordinary piece of insulation will serve the purpose such as asbestos, slate or even wood fiber.

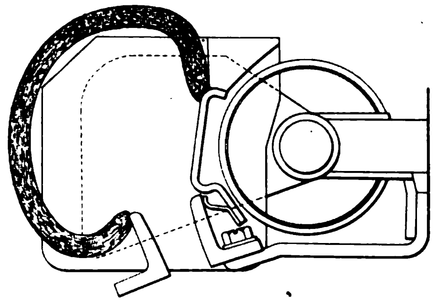
The insulation of the live parts of a magnet contactor or other control devices presents an interesting problem. If the insulation surface is remote from the arc, and the atmosphere reasonably clean, there are many materials that are satisfactory for insulation purposes and only short spacings are necessary. If these surfaces are cleaned from time to time and given a coat of insulating varnish, no trouble should result.

Where the insulation surface is in the neighborhood of the arc a more difficult problem arises. The charged particles in the arc come in contact with the insulation surface and may cause an incipient discharge across this surface. At first this will not be noticed, but in time it may cause sufficient deterioration to result in a flashover. The writer has had many experiences of this kind. One particular case is recalled where a standard piece of control apparatus proved very satisfactory when used with a 7½-hp. motor, but this same controller when applied to a 10-hp. motor on the same service would flash over after approximately 6 mo. use. The controller was restored to its normal condition and was used another 6 mo. This process was repeated several times until we became thoroughly convinced that this particular design was not good for a 10-hp. motor on this service. We often explain trouble with electrical equipment by attributing it to some accidental condition, but if we find that the accident repeats itself several times we should be satisfied that an accidental condition is not the correct interpretation of the trouble.

Another insulation difficulty may be caused by metal fumes being distilled from the material in contact with the arc and deposited on the insulation surface. These fumes should be distinguished from the small metal particles which are separated from the surface by the arc. If high temperatures are experienced in an arc box, care should be taken to use metal which does not give off fumes at relatively low temperatures.

No piece of electrical apparatus should be considered as indestructible. Most maintenance men examine contacts and renew them when necessary, but it is also very desirable to clean the insulation surfaces from time to time and give them a coat of insulating varnish, particularly the surfaces that are in the neighborhood of arcing contacts. Care must be taken in selecting a good grade of varnish and also to avoid injuring the insulation when cleaning it. If in doubt on these two points, you should consult the manufacturer of the apparatus as he knows the composition of the insulation used and can recommend the best method of cleaning and the best varnish to use. The frequency of such overhauling will depend entirely on the service. Nearly all large street-railway companies give their electrical equipment a thorough overhauling at stated intervals. In one large city, I saw control equipment which has been in service for 25 yr. and is still being maintained in first-class condition. Intelligent care will make a wonderful decrease in the depreciation of electrical equipment.

There are two common methods used for rupturing arcs. One is the magnetic blowout and the other, the oil-immersed switch. The latter is not used to any extent for low-voltage control and is limited to alternating-current equipment. From time to time tests have been made on the effect of quenching a direct-current arc under oil, but so far these tests have shown that oil-immersed contacts are not very efficient for opening direct-current circuits. Alternating-current circuits are very effectually opened under oil; the arc is quenched by the oil when the current passes through its zero value. Large amounts of power have been opened in this way with relatively short separation of contacts. The greater the pressure of oil surrounding the arc, the more easily is the arc extinguished.



This shows the effect of a magnetic field on an electric arc.

The arc conductor is extended out in the form of a loop, at a distance considerably greater than that between the two contacts.

The magnetic blowout is used extensively for both industrial and railway control. The arc which is essentially a flexible conductor is moved by a magnetic field in the same direction as the conductor on the armature of a motor. This causes the arc conductor to form a loop extending out from the two contacts, as shown in the illustration on this page, so that its length can be made very much longer than the distance between contacts. The same results could be obtained by separating the contacts, but this would introduce practical difficulties in the design of a magnet contactor. This action of the arc in the magnetic field may be perfectly obvious for direct current, but some of you may wonder what happens with alternating current. The blowout magnet is in series with the arc so that the magnetic field reverses when the current in the arc reverses. This causes the arc to move continuously in one direction, but it is evident that the lag in the magnetic circuit of the blowout coil should be reduced to a minimum, otherwise its effective action is very much reduced. These iron circuits are usually laminated to improve their efficiency. Smaller contactors use solid iron which is slotted to obtain the same results.

In addition to stretching the arc, barriers are often interposed in the path of the arc to make it form several loops which increase its length and at the same time cools the arc by contact with these barriers. Cooling effects are also obtained by forcing the arc through a narrow slot or slots. If the arc is restricted in any way it tends to build up a pressure proportional to the energy being delivered to the arc. This pressure forces the charged particles out through any available opening so that care must be exercised to prevent this charged gas from getting to parts of the switch where it will cause an insulation breakdown. Skill in designing the arc box will eliminate this trouble when the energy of the arc is within the capacity of the switch.

The successful rupturing of the arc depends not only on the voltage of the circuit and the current ruptured, but also on the energy stored in the circuit which is discharged through the arc. Induction stores energy in the circuit in the same way that mechanical energy is stored in the flywheel. We are all familiar with the additional work that is required to stop a motor driving a flywheel on a punch press over that required to stop the same motor operating a plunger pump. In the same way, more difficulty is experienced in opening an inductive circuit than one having only resistance as a load, as may be noted by comparing the flashes in the pair of illustrations on page 414. This point may be proved by using a water rheostat for loading a d.c. generator and then adding a large series motor in the circuit and adjusting the rheostat to give the same current. If an oscillograph is used to measure the voltage across the contacts when the circuit is opened, it will be found that the inductive "kick" has raised this voltage from 40 to 60 per cent above the normal line voltage. This increase in voltage depends on the

amount of induction and resistance in the circuit. The same effect occurs in a.c. circuits and is expressed in the terms of the power factor of the circuit; for instance, it is more difficult to open a given circuit with a 50-per cent power factor than with 80-per cent power factor.

The amount of current that will flow if a short circuit or ground occurs depends upon the amount of power connected to the circuit and upon the impedance of the circuit. If the circuit is fed by a small transformer, the increase in current will cause the voltage to drop and limit the current, as the amount of current = voltage ÷ inpedance. This impedance is made up of both resistance and inductance. Most feeder circuits have sufficient impedance to limit the current to the arc-rupturing capacity of the control. A number of actual tests have shown that the current obtained on short circuit is often less than the calculated amount due to factors which were not considered when the calculations were made. Induction places a direct limitation on the current in alternating-current circuits and retards the increase of current in a direct-current circuit. Quick-acting circuit breakers can be adjusted to open a d.c. circuit before the short-circuit current has reached its maximum value. Usually the feeder circuits to d.c. motors have sufficient resistance to materially limit the short-circuit current and small controllers are protected from short-circuit by fuses which have a high rupturing capacity.

The performance of the arc is different for a.c. and d.c. circuits, and for different voltages. The a.c. arc is frequently broken when the current is near its zero value so in testing it may be necessary to open an a.c. circuit a number of times before the current is ruptured at its maximum value. Alternating currents are generally easier to rupture than direct currents.

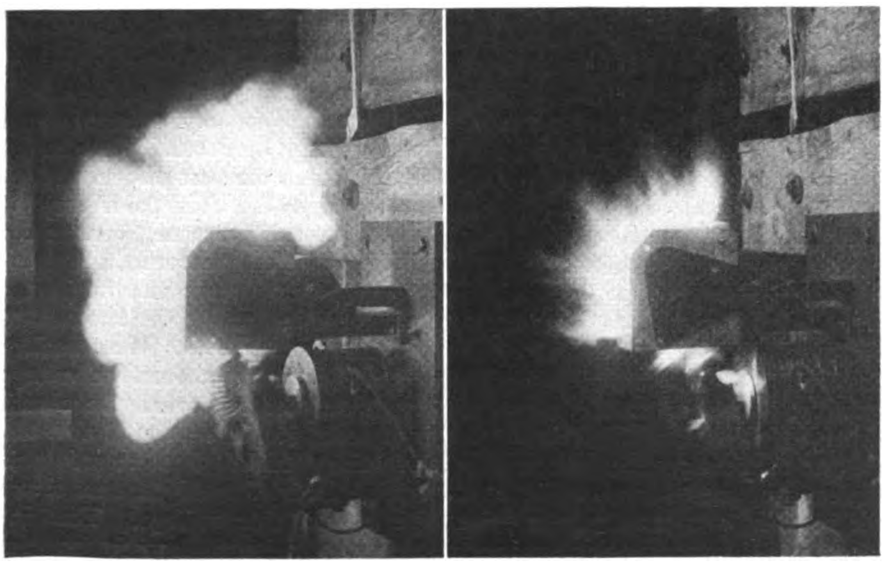
The performance of d.c. arcs on 220, 230, 600 and 3,000 volts are very different. The 600-volt condition seems to be the most difficult. If the 3,000-volt blowout structure is liberally designed so as to properly stretch the arc, very little burning takes place as the current values are small. A recent inspection of some control switches which had been in use on a 3,000-volt locomotive, showed that the burning was very small, even after they had been in service 4 or 5 years. Alternating circuits of 550 volts seem to give the most trouble. The 440-volt circuit appears to be much easier to open than the 550-volt circuit. This deduction may be based on insufficient data but the writer's own experience indicates that the difference in performance between these voltages is quite marked.

Air-break contactors have been built for 6,600 volts a.c., but ordinarily are furnished for 2,200-volt circuits. The motors using these contactors are for hoist duty and may be from 500 to 1,000 hp. in capacity. This service requires frequent operation.

The flash and the noise of the arc when it is ruptured are probably more like artillery practice than ordinary tests in engineering. Even engineers accustomed to this work find it exciting. Perhaps I can describe the sensation of the average person at such a test.

Comparative arc-rupturing tests on a magnetic contactor opening an 825-amp., 500-volt d.c. circuit.

The ease with which the non-inductive circuit at right can be opened as compared to the inductive circuit at left is indicated by the arc.



A group of engineers stand at safe distances around the contactor, preferably towards the front. Each is provided with a colored glass to hold in front of his eyes to protect them from the light of the arc which will also cause the observer's face to become "sunburned." The circuits are carefully checked and the total current in amperes is calculated approximately. The oscillograph, however, will give the correct value. The voltage of the machine is then checked and all is ready for the arc-rupturing test. The circuit may be closed on the contactor or the contactor may be first closed and then the circuit completed through a circuit breaker. The oscillograph operator must have all of his adjustments ready to obtain the instantaneous record.

The oscillograph may be connected so that it starts to take its record when the circuit to the operating coil of the magnetic contactor is opened. One of the testers must stand by the circuit breaker to open it in case the contactor fails.

All of this preparation and the interchange of advice between the different testers adds to the tensity of the situation. The observer usually tightens his muscles and braces himself when the signal is given to complete the test. The trained observer knows what to look for and usually concentrates his attention on some particular detail of the contactor but the novice sees only a great flash and a sharp report, followed by a relaxation of his muscles and a sense of satisfaction that it is over. If the contactor fails to open the circuit, the arc holds on with a noise like a person tearing a cloth. A clean break goes out with a single explosive pop.

Sometimes the arc is ruptured and then reignites several times before it is finally broken. This performance causes a pulsating noise and an experienced observer can usually tell how many times the arc has reignited and can also judge the efficiency of the arc-rupturing performance by the sound and appearance of the flash without looking at the oscillogram of the test.

A considerable number of tests in succession during the day gives the inexperienced person the sensation of exhaustion, because of the work his muscles are required to do unconsciously every time a test is made.

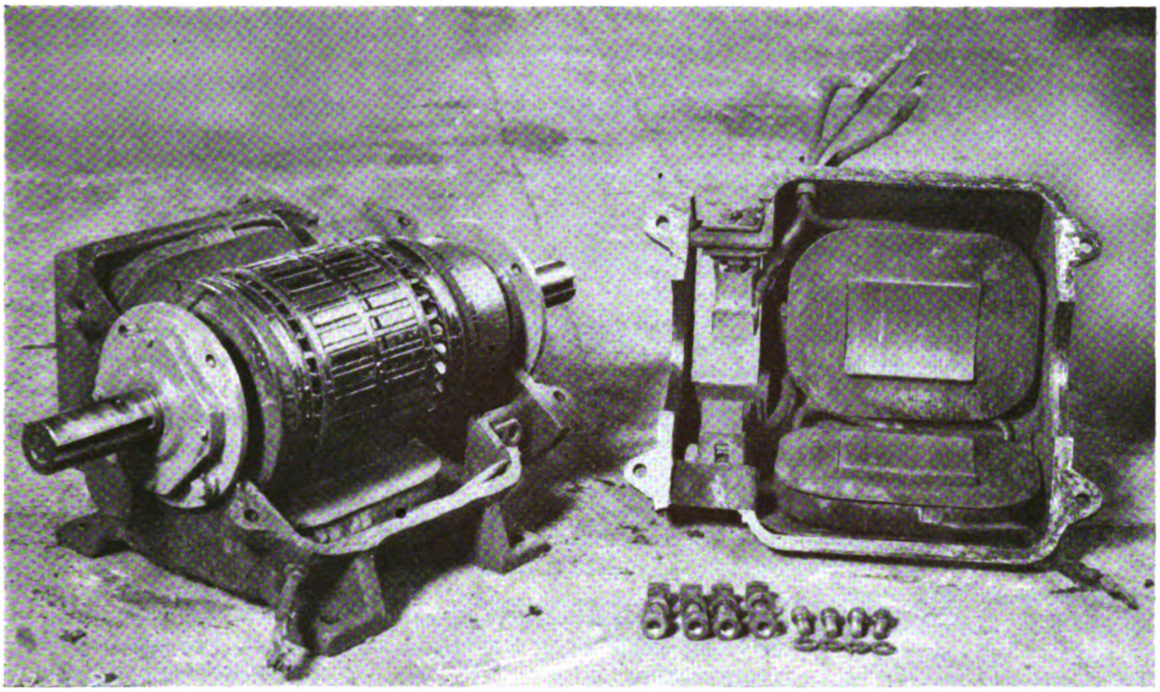


Fig. 1—One of the crane motors rebuilt for ball bearings. Bearing housings that could be attached to the frame by machining were designed for each size of motor.

Details of a simple

Equipment Record System

used in a large steel foundry

By JAMES THOMSON

Chief Engineer, Hubbard Steel Foundry Company, East Chicago, Ind.

IN the maintenance field, comparatively few plants present more serious or diverse problems than the large steel foundry. This does not refer to the size of the jobs nor to the amount of labor involved in performing the work, but to the variety of problems and the need for keeping equipment in as nearly 100 per cent working condition as possible. Because of its 24-hr. operation, the large steel foundry will compare favorably with the steel mill in regard to the need for eternal vigilance to keep the equipment ready for service.

The time when equipment is not at work and available for repairs is short, usually on Sundays only; hence it is very important that everything be done to reduce the necessity for repair to the minimum. This is a matter calling for close observation and study by all who are responsible for the operation of equipment.

In the earlier days of the steel foundry industry, very few companies had any engineering department. Equipment was purchased and installed and the plants run pretty much by the rule-of-thumb method. This naturally lead to rather hit-and-miss methods of maintenance. No adequate records of equipment and its maintenance were kept, and little or no attention was paid to proper design and standardization of equipment for the industry, except in the few cases where those in authority had the foresight to employ engineers from the start. To a large extent, the idea existed that operating methods used in and equipment built for the iron foundry would be suitable for the steel foundry.

In later years some of the companies have seen the value of the foundry engineer who devotes much of his time towards the solution of operating problems, particularly those involved in assuring continuous service. A number of these concerns have established their own engineering departments; others depend upon consulting engineering organizations for this work. Much credit is due to the engineers who have been through the pioneering days of the industry and have helped in the development of plants and equipment suitable for the special needs of this industry. A good deal of the present equipment has been developed as a result of the ideas or suggestions of these engineers, or from their insistence on designs suitable to the needs of the industry. In many cases the foundry engineer has had to practically rebuild existing equipment or to design his own equipment as there was nothing on the market to fit the job. In fact, this is how the manufacture of some of the equipment now available originated. The collaboration of the foundry engineer and equipment manufacturer has had much to do with the development of better and more efficient equipment.

One of the developments which we

have worked on has been the rebuilding of our crane motors to take ball bearings. One of these rebuilt motors using Fafnir bearings is shown in Fig. 1.

The need of careful selection, standardization of parts, improvement, and maintenance of equipment has led to the installation of record and other systems in the plants that have their own engineering departments. These systems vary in the method of recording in the completeness of the information kept on file, depending on how valuable they are considered by the organization, the extent of the co-operation received, and so on.

The system in use by the Hubbard Foundry Co. has been developed through experience covering quite a number of years, and although it is in use in a foundry and machine shop it has some points that may be valuable to those who are associated with other kinds of plants, particularly those in which inevitable interruptions must be cared for in the shortest possible time. In what follows regarding this system no effort will be made to present the details in logical order, but I shall attempt, rather, to bring out some of the features that may be of value to other industrial men who are responsible for the reliability of the plant equipment.

The organization for engineering and maintenance at this plant is really two separate organizations working in close co-operation. The engineering department under the chief engineer handles the plant and product engineering, estimating, construction work, and contract repair work. The actual maintenance work is under the supervision of the master mechanic, to whom the foremen of the various departments, such as the electrical, machine shop, millwright, carpenter and so on, report. While these are two separate organizations there is really that close co-operation which is necessary for the carrying out of the system we use as well as the actual work. The engineering for maintenance work is taken care of by the engineering department and usually the maintenance department assists somewhere along the line during a construction job.

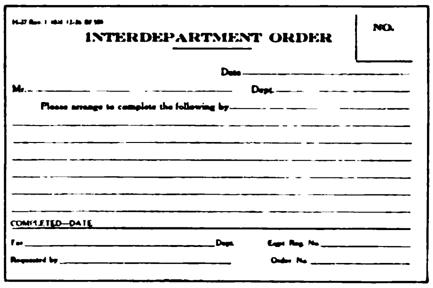

INTERDEPARTMENT ORDER
NO.
Date
Mr. Dept.
Please arrange to complete the following by
COMPLETED—DATE
For Dept. Eqpt. Reg. No.
Requested by Order No.

Fig. 3—This interdepartmental order is used on jobs estimated to cost less than $100.
This order is made out by the foreman of the department in which the work is to be done. The space in the lower right-hand corner is used for entering the equipment register number to facilitate easy reference to the original equipment record, Fig. 2, which will indicate the location of data that might be necessary for carrying out the order.

The selection, design, and installation of equipment and buildings, after the appropriation has been made, are left largely to the engineering department. This has been true for over 10 years, because of additions and growth it has been necessary for this department to keep in close touch with the equipment in the plant. On this account our system has proven invaluable.

Every plant should have an equipment register which should be kept up to date. It would be ideal if such a record could have been started when every plant was installed. Practically this equipment register would provide a continuous inventory of equipment and give the engineering, maintenance, and accounting departments reliable information on the location, life and condition of the equipment.

In our case no such valuable records were started with the plant but the need for them was felt as time passed, so about 2 years ago it was decided to set up such an equipment record. However, it required considerable labor and investigation to get the necessary data, but the effort has been well worth while. When all the available data were obtained, equipment register cards as shown in Fig. 2, were made out by the engineering department. These constitute the engineering record of equipment and from these cards the accounting department gets such information as is needed to set up the equipment ledger.

Each piece of equipment, building and so on, is given a number and all repairs or changes to it are charged to the equipment register number. The records show the department in which this piece of equipment is located and the proper departmental charges are made. For example, a repair to lathe No. L-32 would be charged to the machine shop and against that lathe. In this way not only is the proper department charged with the expense but a record is available of the cost of keeping each piece of equipment operating and there is no need for guessing at the condition. There is also other valuable information on the card such as the name of the manufacturer, equipment data, repair-part list, drive, cost, date of installation, depreciation, rea-

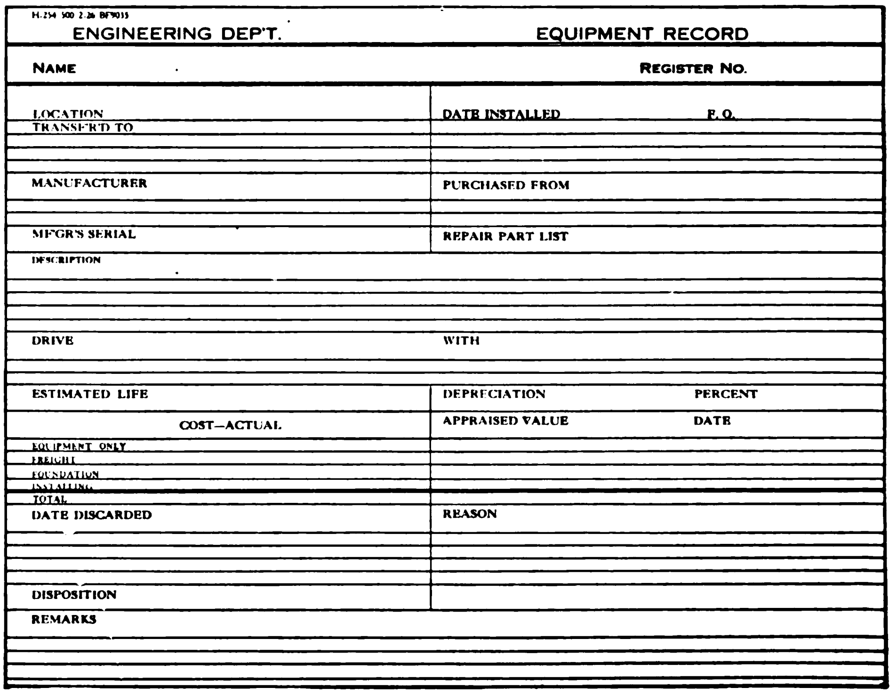

ENGINEERING DEP'T. EQUIPMENT RECORD
NAME REGISTER NO.
LOCATION DATE INSTALLED P.O.
TRANSFER'D TO
MANUFACTURER PURCHASED FROM
MFGR'S SERIAL REPAIR PART LIST
DESCRIPTION
DRIVE WITH
ESTIMATED LIFE DEPRECIATION PERCENT
COST—ACTUAL APPRAISED VALUE DATE
EQUIPMENT ONLY
FREIGHT
FOUNDATION
INSTALLING
TOTAL
DATE DISCARDED REASON
DISPOSITION
REMARKS

Fig. 2—One of these equipment record cards is made out for each piece of plant equipment, and other property.
These cards are made out by the engineering department and from them the accounting department gets such information as is needed to set up the equipment ledger. Also, all repairs are charged to the register number shown on the card. A record of these repairs and costs may be kept on the back of the card if desired, but such information is kept by the accounting department.

Fig. 4—Requisitions for repairs or new equipment costing over $100 are made on this form.

On any such repair jobs, this request for repair or equipment order ties in with the equipment register number. No work, except estimating, is done until approved by the engineering department which then issues the repair and equipment bill of material order.

HUBBARD STEEL FOUNDRY COMPANY

REQUEST FOR REPAIR OR EQUIPMENT ORDER

CLASS ______ EQUIP. REG. NO. ______

PLEASE ISSUE REPAIR OR EQUIPMENT ORDER TO COVER:- DATE ______

CLASSIFICATION OF REQUEST ______ ESTIMATE OF COST REQUESTED BY ______

REQUESTED BY ______ APPROVED BY ______ WORKS MANAGER

FOR DEPARTMENT ______ APPROVED BY ______ VICE-PRES. & GEN. MGR.

ISSUED BY ______ O. K. TO ISSUE ORDER ______ CHIEF ENGINEER

ESTIMATED COST OF ABOVE REQUEST

DETAILS	QUANTITY	PRICE	LABOR	MATERIAL	TOTAL

ESTIMATE APPROVED ______ CHIEF ENGINEER

If this request is for equipment that is to replace obsolete or depreciated equipment, it must be accompanied by REPORT OF EQUIPMENT RETIRED, Form H-315, in accordance with the standard instructions covering the retirement of equipment.

son for discarding, and so on. Although this card might not, in its present form, meet all of the requirements in other plants, it nevertheless fulfilled our particular requirements.

In connection with this equipment register, we maintain a repair-part file in the engineering office which consists of catalogs, repair-parts lists, and such data as is furnished by the manufacturers of the various items of equipment in the plant. With this information, it is a simple matter to order the proper repair parts. In this connection, it is worthy of mention that not enough attention is paid by manufacturers of equipment to the furnishing of proper repair-part lists for the users of their equipment.

Some repair parts are purchased by us but since we operate a foundry and machine shop, we make such parts as we can economically, when time is a vital element.

Repair orders through the plant are handled as follows: if the expense involved is less than $100 for a job, the work is done on an interdepartment order, Fig. 3, which is issued by the foreman requiring the work done. If the expense is estimated at $100 or over it is necessary that a request for a repair and equipment order, Fig. 4, be sent to the engineering department to be properly approved.

The engineering department then issues the repair and equipment bill of material which is the order on which the work is done and from which the necessary material not in stock is ordered by the purchasing department. Accompanying this repair

Fig. 5—Upon the approval of the requisition, Fig. 4, this bill of material and work order is issued.

This order covers the complete repair and overhauling of a crane motor, and describes the material required and the estimated labor cost. In the material specifications column are listed parts which must be purchased, together with the manufacturer's data to guide the purchasing department. Copies of this order are sent to the cost, purchasing, stores, engineering, and two copies to the master mechanic. When the job is completed, rescinded, superseded by another order, or otherwise closed, the perforated coupon in the lower right-hand corner is torn off and sent to the engineering department. When necessary, drawings are made up by the engineering department and sent to the department which does the work along with a copy of the order.

HUBBARD STEEL FOUNDRY COMPANY

REPAIR & EQUIPMENT ORDER BILL OF MATERIAL

COM. BY MN

CK. BY WPB

APP. BY JT

TO COVER: the cost of material and labor for the complete overhauling of M-86 on PL-5.

DELIVER TO: Machine Shop - (PURCHASING DEPT. NOTE: Deliver purchased material to Store Room - Notify F.Dean)

INSTRUCTIONS: PLEASE RUSH THIS ORDER!

R. & E. Order No. 257

Page No. 1

Date Issued Feb.3,1927

For Machine Shop Department

Equip Reg No. M-86/PL-5 Class

Requested By F.Dean

Approved By R.W.F.

	Drawing Number	Mark	Quantity	DESCRIPTION	Pattern Record	LABOR	MATERIAL SPECIFICATIONS
			1	Motor, M-86		Overhaul(complete) - Electrical	
						Dept.	
			1 set	Armature Coils		Install - Electrical Dept.	Purchase
			1 "	Shunt Fields		Ditto	"
			1 "	Series "		"	"
			16	Carbon Brushes		"	"
							The above material for Direct Current, type R-5, No. 2804, 21 Amp., 220 Volt,
							5 H.P., 850 R.P.M., Milwaukee Electric Co.'s motor.

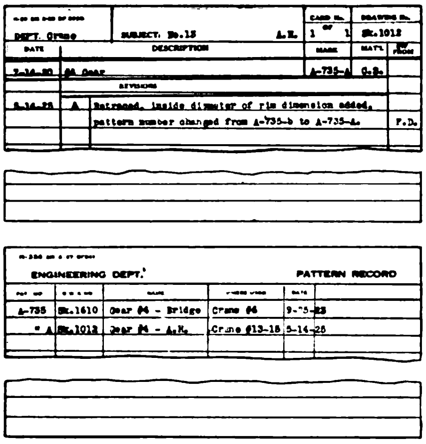
Date Order Completed

Copies of this B/M to the following: Cost, Pur., Stores, M.M.-2, Eng.

R. & E. Order Number 257 Covering overhauling of M-86.

Was ______ On ______ 19__

Signed ______



Figs. 6A and 6B—Records of detailed drawings and patterns are kept on these two types of cards.

These are standard 4x6-in. cards with the necessary headings and spaces printed on them. The description of the revision made on a drawing is noted on the card instead of on the tracing. The pattern record shows every use which may be made of that pattern or of a revised pattern. For example, this gear pattern was used on crane No. 6 before revision and after revision is also used on cranes No. 13 to 15. The method of identification is explained in the text.

and equipment bill of material are such blueprints and specifications that may be required up to this point. In many cases, it is necessary that drawings be prepared before the bill of material, Fig. 5, can be issued. This, of course, delays the issuing of the order but if the drawings are available, that is, from a previous and duplicate order, the bill of material can be issued at once. In case machine-shop work is necessary a separate bill of material is issued setting forth the work that is to be done by the machine department.

An examination of the sample repair and equipment bill of material, Fig. 5, form will show how it is tied into the equipment register. You will also note at the lower right-hand corner a perforated slip, which the person who originally requisitioned the work or equipment is to return to the engineering department to show that the order is complete. The charges for the work are compiled against the repair and equipment order and disbursed by the accounting department when the order is complete.

The success of this order system is predicated on close co-operation of the maintenance and engineering departments. The ruling in the engineering department is that, once any information is obtained about a piece of equipment it is to be put in permanent form, either on a drawing or on file, so that it is available for future reference. This fund of information is of great value to the maintenance department as well as the engineering department and it is referred to constantly.

These two departments have worked out many improvements and have done much in the way of standardization of parts thus reducing the number of repair parts which it is necessary to carry on hand.

Drawings are made on standard-sized printed tracings; the following four sizes are used, 23 x 36 in., 18 x 24 in., 12 x 18 in., and 8½ x 11 in. Because of the bill of material order system, no bill of material is shown on the drawing. New prints are sent out with each order, thus eliminating the danger of using a print which does not embody the latest revision.

As far as practicable on detail drawings, only one important detail is placed on a drawing. This is done to facilitate the work in the shop. As a general rule, only one man works on an operation or a piece of work at a time and by having only one important detail or part on a sheet, the need for more than one man referring to the print at the same time, or, on the other hand, the sending to the shop of a number of prints of the same drawing is eliminated.

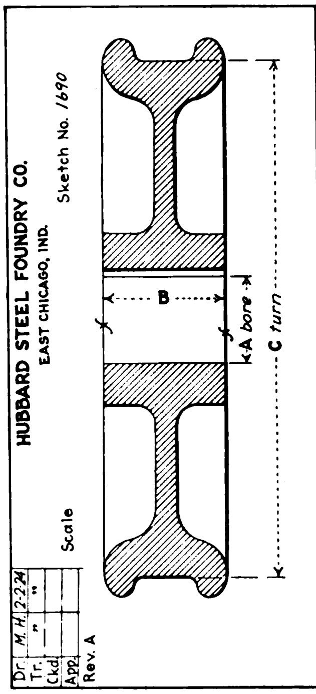
The detail drawings are very carefully indexed on printed 4 x 6-in. cards. One of these is shown as Fig. 6A. This card gives the name of the part, its location in the plant, mark or number, drawing number and date. Below are a number of lines for recording revisions. When a drawing is revised the only notation placed on the tracing is a letter designating the revision and the date of the revision with the checker's initials. All the data of the revision with its designating letter and date are placed on the index card only. This eliminates the crowding of the drawing with a number of revision notes which, usually, are never very clear. Sufficient space must be provided on the card for a complete statement of the revision. The cards are indexed by plant departments, customer, and class, and are thoroughly cross-indexed. This system has passed through several stages of development and has proven very efficient and satisfactory.

The drawings are numbered consecutively and filed in vertical files by size and number in a vault. Foreign blueprints, those obtained from manufacturers of equipment or other outside sources, are also filed in the vault.

Patterns are numbered, not by giving the drawing number and a letter as some companies do, but by a separate letter and number. Each pattern is indexed on a 4 x 6-in. card, which is shown as Fig. 6B. This is

Fig. 7—A page from the Crane Data Book.

The maintenance department is provided with a copy of this crane data book which is made up of 8½x11-in. blueprint sheets which contain the tabulated data collected for practically every piece of equipment which requires renewal or servicing on the cranes. The data are collected, and added to the original tracing, when a crane is taken down for repairs or renewal of the part and the dimensions taken from the original part. These valuable data are then available for any future repair.



CRANE	BORE A	LENGTH HUB B	TREAD DIAMETER C	TEMPLATE	KEYWAY	DRAWING
1	3 5/8"	4 1/2"	18"	T-2	7/8" x 5/16"	SK-377
2	4 5/8"	4 5/8"	18"	T-2	1 1/4" x 15/32"	SK-588
3	6"	4 1/2"	24"	T-1	1 1/2" x 7/16"	SK-400
4	6"	4 1/2"	24"	T-1	1 1/2" x 7/16"	SK-400
5	5 11/16"	10 3/16"	24"	T-1	1 1/2" x 3/16"	SK-12
6	5 3/16"	12"	21"	T-1		SK-1655
7	3 5/8"	4 1/2"	18"	T-2	7/8" x 5/16"	SK-377
8	4 1/8"	12"	18"	T-2		SK-781
9	3 31/32"	5 7/8" 5 5/16"	20"	T-2	1" x 3/8"	SK-1294 SK-1702
10	5 1/2"	5"	27"	T-2	1" x 3/8"	SK-1613
11	5"	4 3/8"	24"	T-1	1" x 3/8"	SK-400
12	4"	4 3/8"	24"	T-2	7/8" x 5/16"	SK-1035
13	4"	4 3/8"	24"	T-2	7/8" x 5/16"	SK-1035
14						
15	4"	4 3/8"	24"	T-6	7/8" x 5/16"	SK-1035
16	4"	4 3/8"	24"	T-2	7/8" x 5/16"	SK-1035
17	6 1/4"	4 15/16"	27"	T-1	1 1/4" x 3/8"	SK-1707

BRIDGE TRUCK WHEELS

printed to carry the history of the pattern as far as changes or its possible use on other machines or equipment is concerned and is tied into the drawing index for other information relative to it.

The pattern-number system used is interesting. The original patterns are in series of 1,000 numbers. Suppose a gear pattern, for example, was numbered *D-236*. If this pattern could be used for another job with a slight change, such as larger hubs, which would not destroy the original pattern, the number would be changed to *D-236-A* by the suffixing of a capital letter. A second pattern change would be *D-236-B*. Suppose on another job the original pattern could be used but the finished gear had some slight change which could be made in machining, as for instance, a slightly narrower face, this would be given the original number with a small letter as a suffix as *D-236-a*, or in the case of changed pattern, such as *D-236-B*, being used with a machining change, the number would be *D-236-Ba*. The capital letter suffix represents a pattern change and the small letter a machining change. The identity of the original pattern is kept by the use of the original number.

This pattern-number system together with the cross indexing of details by class often enables the same drawing and pattern to be used for more than one piece of equipment. For instance by looking over the cards for gears we may be able to use a pattern we have for one job on a new job by making a slight change, and thus save the expense of another pattern.

As stated before, the engineering department is constantly trying to standardize parts and improve design so as to lessen the number of spare parts to be carried and reduce maintenance expense. In this work a great amount of information has been tabulated.

As this tabulated information is put in shape it is given to the maintenance department for their use. Having this data at hand lessens the uncertainty of their work and enables them to foresee their needs.

The use of this tabulated data is well illustrated by taking the cranes for an example. The maintenance department is provided with a crane-data book two pages of which are shown in Figs. 7 and 8, which contains the following information for each crane: motors and controllers, truck wheels, couplings, motor brushes, cables, gears and other parts. With these tabulated data, which are on 8½ x 11-in. blueprinted sheets, the correct parts can be picked out of stock for a repair job even without the detail drawings. Having this information also enables the maintenance men to make comparisons which assist in standardization of parts. It also assists them in keeping their stock of parts up to the correct standard, but if by some slip it should occur that a part is not available when needed, comparisons can be made and perhaps a similar part changed slightly to take care of the emergency.

Much attention has been given to improvement in design to lessen maintenance expense and keep the equipment ready to serve as nearly as possible 100 per cent of the operating hours. This, at times, has led to rather drastic changes from the original design. Referring again to cranes, which by the way are a source of continual watchfulness in a large steel foundry due to the hard use given them, often bordering on abuse, and the dusty conditions in which they must work, we have gone to the use of Cincinnati Tool Steel and Pinion Co.'s "Tool Steel" pinions and truck wheels; alloy steel shafts, steel couplings and ball-bearing motors.

We have been ridiculed about the ball-bearing motor idea in the past, but as our satisfactory experience extends over a period of about 5 years we believe we are not wrong. The

(Please turn to page 435)

Fig. 8—This is a repair-part page from the Crane Data Book.

The maintenance department may order a repair part by referring to this page from the data book, before they begin to dismantle the crane. If the part is in stock, it can be delivered to them immediately; otherwise, purchase or manufacture is ordered at once. An inspection of the data often indicates that a part intended for another crane may be used. The blank spaces indicate places where as yet the information has not been collected. These data are built up over a period of years.

DR.	L.R.I.	8-7-23
TR.		
CHD.		
APP.		

HUBBARD STEEL FOUNDRY CO.

EAST CHICAGO, IND.

SKETCH NO. 1156

GEAR DATA - CRANE No. 16 MAIN HOIST 10 TONS AUX. HOIST 3 TONS

	GEAR NO.	NO. TEETH	D.P.	P.D.	O.D.	F	B	LGTH HUB	C-E HUB	C-E HUB	DIA. HUB	KEY WAY	PATT. NO.	DWG. NO.	REMARKS
MAIN HOIST	1	22	4	5 1/2"	6"	3 1/4	2 1/8	3 1/2	1 3/4	1 3/4	4 1/2	1/2" x 3/16	S.F.	SK 1071	
	2	82	4	15.5"	16."	3"	2 3/4	4	2"	2"	4 3/4	5/8 x 3/16"			
	3	18	3 1/2	5.143	5.714	3 3/4	2 3/4	4 1/4	2 1/8	2 1/8	4"	5/8" x 3/16"	S.F.	SK 1078	
	4	88	3 1/2	19.428	20"	3 1/2	3 5/8	4 7/8	2	2 7/8	6	7/8 x 1/4		SK 1—	
	5	15	2 1/2	6"	6.8"	4 3/4	3 5/8					7/8" x 1/4"	S.F.	SK 1077	
	6	65	2 1/2	26"	26.8	4 1/2	16 3/4					3/4" x 1/4"			
AUX. HOIST	1	16	4	4"	4 1/2"	3 1/4	1 7/8					1/2" x 3/16"	S.F.	SK 1079	
	2	50	4	12.5"	13"	3"	2 1/4	4 1/8	1 1/2	2 5/8	4"	1/2 x 3/16"			
	3	18	4	4 1/2"	5"	3 1/4	2 1/4	4 1/4	2 5/8	1 5/8	3 3/4	1/2" x 3/16"	S.F	SK 1080	
	4	86	4	21.5"	22"	3"	2 7/8	3 3/8	1 1/2	1 7/8	5 5/8	5/8" x 3/16"	A-735-b	SK 1012	
	5	17	3 1/2	4.857	5.429	3 3/4	3 1/8					1/4" x 3/4"	S.F.	SK 1013	
	6	74	3 1/2	21.143	21.714	3 1/2	14 3/4					5/8" x 3/16"			
TROLLEY	1	14	5	2.8"	3.2"	2 3/4	1 1/2					3/8" x 1/8"	S.F.	SK 1072	
	2	41	5	8.2"	8.6"	2 1/2	1 3/4	3 1/8	1 3/8	1 3/4	3 1/4	1/2" x 3/16"	C-385	SK 1074	
	3	19	5	3.8"	4.2"	2 3/4	1 3/4					1/2" x 3/16"	S.F.	SK 1073	
	4	46	5	9.2"	8.6"	2 1/2	1 3/4	2 5/8	1 1/4	1 3/8	3 1/4	1/2" x 3/16"	C-384	SK 1076	
	5	13	4	3 1/4"	3 3/4"	3 1/4	1 3/4					1/2" x 3/16"	S.F.	SK 1075	
	6	52	4	13"	13.5"	3"	2 5/8	3 1/4	1 5/8	1 5/8	5"	5/8" x 3/16"	C-521	SK 1553	
BRIDGE	1	30	4	7.5"	8"	3 7/32	2 13/16					5/8" x 3/16"	S.F.	SK 1857	
	2	66	4	16.5"	17"	3"	5 1/2	3 1/8	1 1/2	1 5/8	7 1/2	5/8" x 3/16"	C-236	H-9345	TAPER KEYWAY
	3	22	3 1/2	6.286	6.857	3 3/4	4 1/2	6 7/8	1 7/8	5"	5 1/2	5/8" x 3/16"	S.F.	H-9345	
	4	88	3 1/2	12.714	18.285	3 1/2	4 3/4					5/8" x 3/16"	C-236	H-9335	TAPER KEYWAY
	5	15	2 1/2	6"	6.8"	4 3/4	3 5/8	8 1/4	2 3/8	5 5/8	4 3/4	5/8" x 3/16"	S.F.	H-9335	
	6	45	2 1/2	18"	18.8"	4 1/2	3 13/16	4 19/32	2 1/4	2 9/32	6 1/4	7/8" x 1/4"	C-137	SK 1265	

BRIDGE-MILWAUKEE 10 TON No. 419 TROLLEY-MILWAUKEE 10 TON No. 419

Recent developments in

Electric Drives for Rolling Mills

By L. A. UMANSKY
Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.

THE iron and steel industry is the largest single consumer of electric power. In 1924 this industry used more than 6,000,000,000 kw-hr., which is about 20 per cent of the total power consumed by all industries in the United States.

A modern steel plant, starting with iron ore as a raw product, produces at its blast and open hearth furnaces and at the coke ovens a large amount of waste gas or heat. Electricity gives means of conveniently converting and transmitting this potential power to the centers of its consumption.

So great is the demand for power in the steel industry that even plants having their own blast furnaces often purchase additional power from public utilities. Many other plants, deprived of the use of blast furnace gas, run almost exclusively on purchased power.

The bulk of this vast amount of energy goes for the work of shaping the steel. The rolling mill drives are the principal outlets of the generated power. Here the electric drive predominates. Hardly any new mills are being equipped with anything but electric motors. Older steam driven mills are being gradually electrified, for purely economic reasons.

Many electrical engineers, not connected directly with the steel industry, may not fully realize the profound, almost revolutionary changes which electric drive brought about in the rolling mills. It is not merely the question of performing the operations in a better, more efficient, or more reliable manner than otherwise possible; but the point, which is sometimes lost sight of, is that many operations and processes, now in wide use, are practically impossible without the agency of electric power. Rolling mill designers have taken advantage of the possibilities of electric drives and have built mills on radically new principles exceptionally advantageous for steel plants, but not practical, were it not for the presence of electrical motors. On the other hand, the electrical engineers have developed new machines, or new combinations of machines, primarily, if not exclusively, for rolling mill application. Thus the new rolling mill has become closely tied to its drive and is unthinkable without it. The influence between the electrical and mechanical equipments is now not only great—it is also mutual. New problems were brought up and many were solved more or less successfully.

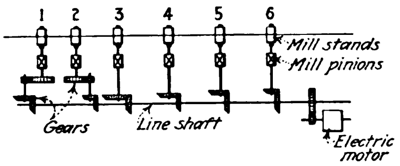


Fig. 1—Elementary diagram of a continuous mill with a single drive.
A number of two-high stands arranged in tandem and conventionally driven through a line shaft and gears by a single motor. The hot bloom or bar passes in succession through all stands, as indicated by the arrow. Each pair of rolls reduces the cross section of the bar until the latter leaves the last stand as a finished product of the desired shape.

It has been generally recognized that for a large tonnage output a continuous rolling mill possesses decided advantages. In this type of mill which is illustrated schematically in Fig. 1, the layout is compact; little heat is lost between stands; the metal is rolled at a high temperature and with a relatively low power consumption; the steel requires little, if any, handling; and also the labor costs per ton are reduced to a minimum. The bulk of the country's steel output passes through a continuous mill of one kind or another. To maintain the high tonnages and to keep the cost of handling down, the rolled bars are usually of considerable length; a finished length of several hundred feet is quite common. In order to save floor space the stands are located close to each other. This means that the metal is in several stands at the same time. It is obvious that with such an arrangement the speed of each consecutive pair of rolls is increased in proportion to the reduction of the cross-section area. For a given mill the speed relation between stands is fixed and is determined by ratio of the several gears; hence the reductions per pass, or the so-called drafts, are also more or less fixed. Thus, a continuous mill of the outlined type, capable of producing large tonnages of a certain class of sections, is not quite flexible when it comes to rolling a diversified line of products.

Individual drives for several stands of a continuous mill as shown in Fig. 2 give it the necessary flexibility, at the same time maintaining its inherent advantages.

If all motors, or several of them, are of the adjustable speed type, then the speed ratio between the stands may be readily changed. A wide variety of products may be then successfully rolled, each at its proper speed, each with the most suitable reductions at the several stands.

Mills, designed and built on this principle, are springing up all over the country. Hot strip, rods, merchant bars and certain structural shapes are being rolled on such mills. They are believed to be economical, flexible and tonnage producing. In many cases one mill of this type takes the place of two or three less modern mills.

This is an abstract of a paper that was presented by Mr. Umansky at a regional meeting of District No. 2, of the A.I.E.E., recently held in Bethlehem, Pa.—EDITORS.

Such layouts would be hardly feasible were it not for the application of the electric motor. We are inclined to accept it as a matter of fact, that there is no other device which can concentrate a large bulk of power in a limited space. It is efficient even in small units, is capable of speed adjustment, and will closely maintain its speed once it has been adjusted.

It is outside the scope of this paper and outside the competence of the writer to offer a thorough analysis of mill layouts from the standpoint of rolling mill operations. It was not intended to convey the idea that, for instance, a continuous mill with individual drives is the best combination or layout for all applications; such a mill was merely discussed in order to illustrate the profound influence of electricity on rolling mill engineering and practice. However, it will be shown presently how the electrical engineers are providing suitable drives for mills of the kind just described. While no radically new machine was invented nor introduced, some new combinations of machines were conceived and were successfully applied.

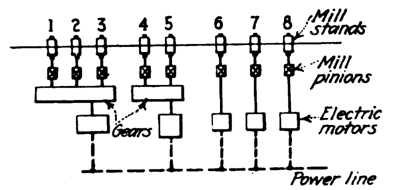


Fig. 2—Elementary diagram of a multi-drive continuous mill.

The first three roughing stands are driven by one motor, the next two stands by another motor and the last three, or finishing stands are each provided with a separate drive. The hot bloom or bar passes in succession through all stands, as indicated by the arrow.

When a mill requires a number of adjustable speed drives it is the simplest and, in many cases, the best way to make each drive a d.c. motor and to furnish power to them from motor-generator sets or from synchronous converters. The schematic layout of one of the most modern mills of this type is shown in Fig. 3.

All motors are 600-volt, d.c. machines and the power to them is furnished from three large synchronous motor-generator sets, aggregating 12,200 kw. (40 deg. cent. continuous capacity). Practically each motor has a corresponding generator, as is shown on the diagram. Ward-Leonard control is used for starting, and the combination of generator voltage and motor field control gives a very wide speed range (as wide as 4:1 and 5:1) to each drive.

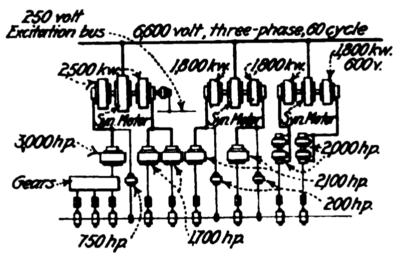


Fig. 3—This is a schematic layout of a large continuous mill driven by d. c. motors.

A 3,000-hp., 200/360-r.p.m. motor drives the roughing train of three stands; two 1,700-hp., 90/204-r.p.m. motors and two 2,100-hp., 150/460-r.p.m. motors are individually driving the next four stands; the two finishing stands are each driven by double-unit 2,000-hp. motors consisting of two 1,000-hp. armatures which can be connected either in series or in multiple and operating up to 800 r.p.m. Three smaller edging roll stands are also electrically driven.

Another interesting example of a modern mill with stands individually driven by d.c. motors is represented by the layout in Fig. 4. The capacity of each drive is indicated on the diagram. The power to the motors is supplied from a 3,000-kw., 600-volt, three-unit motor-generator set. Ward-Leonard control is used for starting. and motor field control for speed adjustment.

The art of engineering thus far knows of but one way to built adjustable speed, a.c. drives, of such capacities as are involved in steel mill work. This is to use a slip-ring induction motor and to regulate its speed by acting on its secondary circuit in one or another well known manner. These methods have been described in great detail at various times and the most representative of them are diagrammatically shown in Fig. 5.

All these methods have one thing in common. An induction motor, running at a synchronous speed, delivers at its shaft as mechanical energy, only that portion of the power transmitted to the rotor which is proportional to the speed. The balance of this power proportional to the slip, is available at the slip-rings and is usually called the slip energy, which is of a frequency and voltage proportional to the slip. This energy is either converted into mechanical power and is returned to the main motor shaft, see Figs. *B, D, F*, or is converted into electric power of the line frequency and voltage and is returned to the a.c. system; see Figs. *A, C, E*. In the first case the drive is of a "constant horse power" type, as approximately the same amount or power (neglecting conversion losses) is available at the motor coupling at all operating speeds; in other words, larger torque is available at the reduced speed. In the second case the drive is of "constant torque" type, that is, the power available at the coupling varies with the speed.

In Fig. 5, *A* and *B* represent the Scherbius system employing an a.c. polyphase commutator motor *R* to convert the slip energy into mechanical power at its shaft; then it is either returned electrically to the line through an induction or synchronous generator *K*, or is utilized directly on the drive shaft. The regulating machine *R* is shunt wound and is excited from the slip-rings of the main motor. By controlling the amount of excitation the speed of the drive may be adjusted suitably.

In the Kraemer system, which is shown at *C* and *D*, Fig. 5, the slip energy is converted into d.c. power by means of a synchronous converter *G*. This d.c. power (of variable voltage) may be also either pumped back to the line through a motor-generator set *N-K*, as in *C*, or returned mechanically to the main motor shaft, as in *D*. In either case the speed of the drive is adjusted by controlling the excitation of the motor *N*.

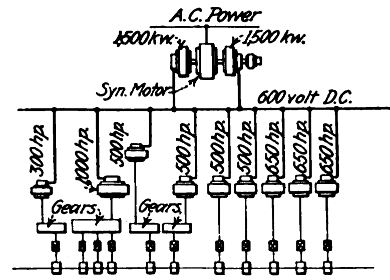


Fig. 4—Here is a typical arrangement of a moderate size continuous mill driven by d. c. motors.

The power to the motors is supplied from a 3,,000-kw., 600-volt, three-unit motor-generator set. Ward-Leonard control is used for starting and motor field control for speed adjustment.

Or, the slip energy may be transformed by means of a frequency converter, *P*, which is shown in *E* and *F* in Fig. 5, running at the motor speed, and a regulating transformer, *T*, as in *E*, into line frequency and voltage. Finally, it may be converted suitably by a frequency converter, as in *F*, separately driven by a small synchronous motor, *A*, and is then returned as mechanical power to the main shaft by means of a synchronous motor, *S*; its excitation provides the speed regulating means. Several

other schemes, employing a frequency converter, are also conceivable.

Either scheme is capable of regulating the speed of the main motor not only below but also above synchronism, forming a so-called double range drive. Obviously the slip energy is then of a reverse direction; it flows from the regulating machines to the slip-rings, and not from them; the dotted arrows in Fig. 5 indicate that the flow of power will have to be reversed. The Scherbius and the frequency converter systems are usually of the double range type, on account of certain difficulties of operating the Kraemer drives close to synchronism (that is, at a very low frequency at the synchronous converter G) and of inability to go through synchronism under load, these drives are usually built as single range equipments, for sub-synchronous operation only.

It will be observed that with all of these schemes the main part of the a.c. power is converted but once until it reaches the mill coupling; only the balance of power or the slip energy goes through more than one transformation before it is utilized. Naturally, the over-all efficiency is higher than with the d.c. drives and is usually around 90 per cent at full load. The machines used for speed regulation should have a capacity depending on the size of the main motor and on the amount of speed range. Therefore, the greater the speed range, the more expensive becomes the a.c. speed regulating equipment, and the less becomes its advantage over a d.c. drive, both from the standpoint of first cost and efficiency. Obviously, with a double-range drive, the same speed regulating equipment is utilized to a greater extent than with a single-range drive.

While some of the outlined a.c. systems were widely used during the last 10 or 15 years, their application for multi-drive mills, gives the engineers an occasional opportunity to get off the beaten track, and to group the well known machines in some new and more advantageous arrangement. The underlying principle of

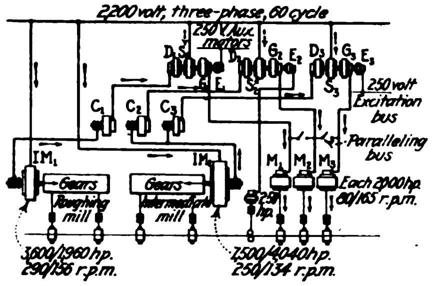


Fig. 6—Electrical arrangement of combination a. c. and d. c. drives for a large continuous mill.

This sketch represents a single line diagram of a large continuous rolling mill equipment recently put in operation in the Chicago district. For the sake of simplicity, the switching and control apparatus are not shown. The mill consists of several stands arranged in tandem. The roughing stands were to be driven by one motor, developing 3,600 hp. at 290 r.p.m. and 1,960 hp. at 156 r.p.m. The intermediate train was to be driven by another motor, developing 7,500 hp. at 250 r.p.m. and 4,040 hp. at 136 r.p.m. The three finishing stands were to be each driven by a 2,000-hp. motor, developing this capacity at any speed 85 to 165 r.p.m. A set of edging rolls required a 250-hp. drive. The electric power was available at 2,200-volts, three-phase, 60-cycle.

several new combination drives is this:

If the slip energy, contingent on speed regulation of one or several a.c. drives, need not be returned to the shafts of these drives, it may be made use of for furnishing, completely or in part, the power required to drive some other sections of the same mill, or some other mills.

This principle was applied for the first time in 1925 in connection with the equipment shown in Fig. 6 and, to the best of the author's knowledge,

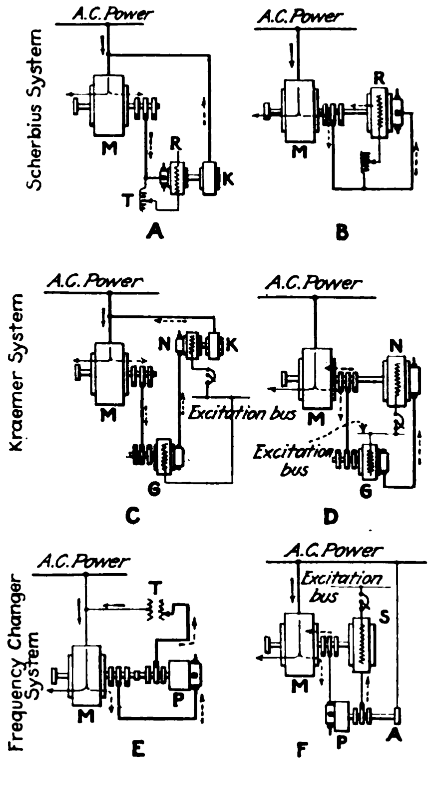


Fig. 5—Elementary diagrams of several a. c. adjustable-speed drives.

The slip energy is converted into mechanical power at the shaft or returned electrically to the line. A and B represents the Scherbius System, C and D, the Kraemer System; E and F represent the Frequency Changer System, wherein this slip energy goes through more than one transformation before it is utilized while the main part of the a.c. power is converted but once before it reaches the mill coupling.

it has not been suggested nor applied previously. The electrical engineers have solved the problem of selecting the drives for this mill in the following manner:

The 3,600-h.p. and 7,500-h.p. drives, being large units running at reasonably high speeds, could be economically designed as induction motors, with speed adjusted by the Kraemer method. The finishing mill drives, smaller in capacity and much lower in speed, could be more advantageously and more compactly built as 600-volt, d.c. motors, with speed adjustment by motor field control. The power to these motors is furnished from three 1,700-kw. 600-rev. per min. d.c. generators, *G1, G2* and *G3*, driven by synchronous motors, *S1, S2* and *S3*. Low-speed, 60-cycle induction motors for driving the three finishing mills would be expensive machines with a rather poor power factor, and the use of reduction gears would not be very advantageous, nor feasible, due to certain local conditions.

It will be observed that the 3,600-hp. induction motor *IM-1* when running at 156 r.p.m. (that is, at 52 per cent synchronous speed), is required to develop only 1,960 h.p. as mechanical power at its shaft; the other 48 per cent or 1,640 h.p. are available as slip energy. The latter is converted by means of the synchronous converter *C1*, into d.c. power and drives a d.c. machine *D1*, as a motor. The excitation of the latter determines its voltage and, therefore, the speed of the drive *IM-1*.

Likewise, the 7,500-h.p. motor, running at 136 r.p.m. or 52 per cent synchronous speed, delivers to the mill 4,040 h.p., while the available slip energy amounts to 3,460 h.p. It is converted to d.c. by means of two synchronous converters, *C2* and *C3*, duplicates of *C1*, and is used for driving the d.c. machines, *D2* and *D3* as motors; by changing simultaneously the excitation of *D2* and *D3* the speed of the drive *IM-2* is adjusted. As the maximum amount of the slip energy to be handled by each of the machines *D1, D2* and *D3* is approximately 1,750 h.p., they are made exact duplicates of the 1,700-kw. generators, *G1, G2* and *G3*.

Arrows on Fig. 6 indicate the flow of power when the entire mill is in operation. It will be seen that the machines, *D*, are running as motors and are assisting the synchronous motors *S*, in driving the generators *G*. This assistance is the

greater, of course, the lower the speed of the drives *IM-1* and *IM-2*; if this speed is close to synchronism, or if the load on the drives *IM-1* and *IM-2* is relatively light, then the synchronous motors are more heavily loaded. In the extreme case they should be capable of furnishing the total power required by the generators and cover the friction and windage of the machines *D*. In other words, the synchronous motors need be only 50 per cent of the capacity required for a three-unit motor-generator set of the same d.c. rating.

Ordinarily, the motors *S*, would be running underloaded, providing an additional amount of leading kva., and compensating for the reactive kva. of the large induction motors. The power factor of the whole installation is approximately 97 per cent leading at full load.

Thus the slip energy of the constant torque drives *IM-1* and *IM-2* is not returned mechanically to the shaft of these drives where it was not required in this case, nor is it returned electrically to the power bus. Instead of this, it is made use of in a more direct manner; namely, for driving the finishing mills. The over-all efficiency is improved and the required capacity of the regulating apparatus is reduced to a minimum.

The drive just described possesses a number of secondary advantageous points, although these are not directly connected with the new principle of utilizing the slip energy. For instance, in case of light loads, it is possible to operate the drive *IM-2* with only one synchronous converter and one d.c. motor, say with *C2* and *D2*, and to operate the three d.c. motors *M1*, *M2* and *M3* from only two generators, say *G1* and *G2* by using the paralleling bus. This will permit the shutting down of one motor-generator set, thereby reducing the running-light losses. Although it is hard to estimate with any degree of accuracy the resultant saving in power, it is evident that any such saving is a net gain. It may be said in this connection that in steel mill drives, which are usually liberally motored to take care of the maximum load conditions, the low-running light losses are just as big a factor in conservation of power as the high efficiency.

Another continuous mill, now being built for a large eastern steel manufacturer, will be equipped with electric drives embodying to a smaller extent the same principle; several new features of a different nature will make a brief review of this equipment rather interesting. In this case the mill will have a number of stands arranged in tandem, as shown diagrammatically in Fig. 7. The rolling requirements being different, the first several stands will be driven by constant speed motors. The power supply is 6,600-volt, 25-cycle.

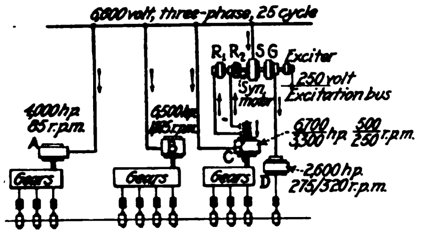


Fig. 7—Arrangement of electric drives for a large continuous mill. Two synchronous motors, one Scherbius equipment and one d.c. motor aggregating approximately 20,000 hp. continuous capacity will be used for driving this mill.

The roughing train will take a 4,000-hp., 83.3-r.p.m. motor A, the intermediate train will be driven by a 6,500-hp., 187.5-r.p.m. motor *B*. The following group of stands will be jointly driven through a train of gears by an adjustable-speed equipment *C*, developing 6,700 h.p. at 500 r.p.m. and 3,350 h.p. at 250 r.p.m.

The last finishing stand will take a separate direct-connected drive *D*, with an output of 2,600 h.p. at a speed of 275 r.p.m.; constant-horsepower output will be maintained for speeds above 275 r.p.m. and reduced output on constant-torque basis, for speeds below this value.

These drives will never be required to start their respective mills with metal in the rolls. Mill friction on a cold winter day after a prolonged shutdown would be the most severe starting condition. Several tests have shown that a torque of about 25 or 30 per cent normal will start a continuous mill under most adverse conditions.

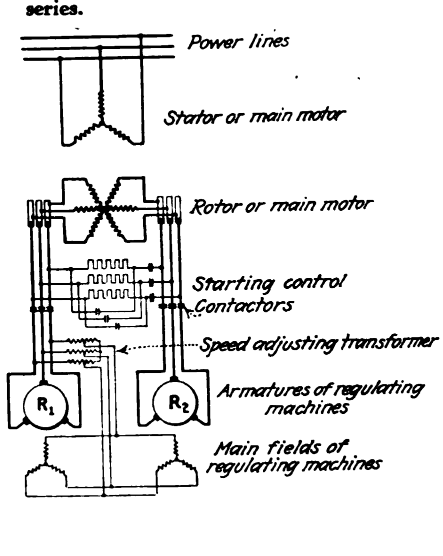


Fig. 8—Elementary diagram of electrical connections of a Scherbius adjustable speed drive with two regulating machines connected in series.

Actual experience with a 9,000-h.p., 107-r.p.m., synchronous motor, driving since the summer of 1926, a large continuous rolling mill at the McKinney Steel Company, Cleveland, Ohio, has proved conclusively that a synchronous drive is quite applicable for mills of this nature. This synchronous motor is capable of developing a starting torque of 265 per cent normal if started on full voltage. It is usually started on a low voltage tap of an auto-transformer, developing the starting torque actually required with considerably less than normal line kva. input.

Under the circumstances it has been decided to build the drives *A* and *B* as synchronous motors and to take advantage of their leading kva. for power factor correction of the steel plant.

The large adjustable-speed drive *C*, will consist of a 5,000-h.p., 375-r.p.m. slip-ring induction motor, the speed of which will be adjusted to 33 per cent above and to 33 per cent below synchronism (that is, from 500 r.p.m. to 250 r.p.m.) by means of the two Scherbius regulating machines *R1* and *R2*. With this constant torque layout, the capacity of the drive will be 6,700 h.p. at 500 r.p.m. and 3,300 h.p. at 250 r.p.m. An a.c. drive of such capacity and speed can be built more economically and with a much higher efficiency than any combination of d.c. machines. The fact that the power supply was 25-cycle gave the Scherbius system an advantage over the Kraemer drive.

The last finishing mill drive *D*, will have a wider speed range, is of smaller capacity and runs at a lower speed than the drive *C*. While a Scherbius equipment for the drive *D*, would be fully competitive in first cost, the difference between it and that of a d.c. was not as wide as in the case of the drive *C*. For the sake of greater flexibility of control it was decided to make the drive *D* of the d.c. type.

A 500-r.p.m. synchronous motor *S*, will drive a 2,300-kw., d.c. generator *G* (furnishing power to the motor *D*) and the two 650-kva. Scherbius speed-regulating machines *R1* and *R2* used for adjusting the speed of the induction motor *C*. When the motor *C* runs below its synchronous speed, the slip energy flows to the machines *R1*

and *R2;* the latter run as motors and assist the synchronous motor *S* in driving the generator *G*. In other words, the slip energy does not have to be returned as electric power to the incoming line; instead of this, it may be used for driving wholly or in part, the finishing mill *D*. The flow of power is indicated by arrows. This is another application of the same principle which was illustrated in Fig. 6.

When the drive *C* is running above synchronism, the slip energy becomes negative and arrows shown by the dotted lines in Fig. 7, will be reversed. The machines *R1* and *R2* act then as generators, and derive their power from the synchronous motor *S*. A direct-connected exciter provides the necessary 250-volt excitation to the synchronous motors *A, B* and *S,* and to the d.c. machines *G* and *D*.

The use of two regulating machines *R1* and *R2* for controlling the speed of the motor *C* presents some interesting features. The maximum amount of the slip energy to be handled by the speed regulating equipment is 1,700 hp. It is not practicable to build an a.c. commutator machine of such capacity to run at 500 r.p.m., so a lower speed such as 375 r.p.m. or 300 r.p.m. would be required. With the proposed layout such reduced speed would considerably increase the cost of the d.c. generator *G* and of the motor *S*. It would be still more expensive to provide a separate low-speed drive for the regulating machines *R1* and *R2,* and to drive the generator *G* by another 500-rev. per. min. motor. It was quite advantageous, therefore, to split the capacity of the regulating equipment in two units and to run them at 500 r.p.m.

The connections of the regulating machines to the secondary winding of the induction motor are shown in Fig. 9. The 5,000-hp. motor is equipped with six slip-rings, with both ends of each phase of the rotor brought out. Each set of three slip-rings is connected electrically to the commutator of the regulating machines *R1* and *R2,* which thus forms the two Y-points of the secondary circuit. In other words, the two machines *R1* and *R2* act as if they were connected in series with each other, their emf.'s added together. The shunt fields *F1* and *F2* are adjusted simultaneously by a common-speed control apparatus.

By disconnecting one regulating machine and by short-circuiting the corresponding set of slip-rings, it is still possible to operate the drive with the other regulating machine. Full torque of the drive will be obtainable, but the speed range will be cut in half; that is, it will be in this case approximately 312 to 437 r.p.m.

None of the several electrical layouts described on the preceding pages should be considered as anything more than what they were originally intended for: A good combination of electrical machines to fit a set of given requirements. Certain principles may be used again in some future drives. The whole combination may never be repeated. Electric drives for modern large rolling mills can hardly be standardized. They rather are and may be called "custom made," designed to fit individual cases.

Many single mills require up to, or over, 20,000 h.p. in electric drives; investment runs into several hundred thousands of dollars; the cost of power consumed in a year may approach the same figure. This alone justifies a thorough engineering study and a preparation of an individual layout for each case. Machines of special design need not necessarily be built for any new drive, but there is usually a broad field for working up a good new combination of apparatus.

It was the intention to point out, by means of the several illustrated schemes, that such an opportunity is present in most cases and that the electrical engineers seldom let such opportunities slip by.

Safety Rules for the Guidance of Crane Operators

AT ONE of the large iron and steel works, considerable importance is attached to certain rules governing the duties of the operators of cranes. In order that their operators may be at all times familiar with these rules, an enameled plate of these regulations, which reads as follows, is hung in each crane cage:

(1) No one but a regularly authorized operator is allowed to use this crane.

(2) You must thoroughly inspect your crane at the beginning of each turn and see that all bolts and nuts are tight, and that all chains and cables are in safe condition.

(3) You are forbidden to operate your crane when it is not in a safe condition; report immediately to your foreman on discovering any defects.

(4) Do not operate your cranes when anyone is working on your crane runway or any runway adjacent thereto, unless authorized to do so by the foreman in charge of crane repairs.

(5) Do not move without a signal from the proper man. See that the trolley is directly over the load, to prevent swinging. Be sure that every one is "Clear"; ring gong; start slowly.

(6) Do not carry load over men on the ground; use gong. Watch your empty hooks.

(7) You will be discharged if you allow anyone to ride on the load or on crane hooks.

(8) All safety devices must be maintained; operators showing a disregard for safety will be discharged. Keep your crane clean. Do not allow loose material to remain on it or on the runways.

(9) Do not leave your crane cab without first pulling out the main switch; when going up on top of the crane for any reason, put a red flag in open switch.

(10) No repairman shall make any repairs without first locking the main switch open and hanging a danger signal on the crane directly underneath work being done.

In an extreme case when the crane has to make a lift before repairs are finished, the craneman is thoroughly instructed by the foreman in charge of the shop or by the electrician. The operator will understand that each move to be made will be upon signal from the one who has just given him his instructions. The foreman or electrician will also see that each man on the job is in a safe place before signaling the craneman to move. In this case the lock on the switch is temporarily removed by one of the repairmen on the job and replaced by him when the movement is completed. Strict adherence to these rules has a tendency to lower accidents because definite responsibility is fixed for the movement of the cranes. The crane operator by virtue of these rules has certain authority in so far as the operation of the crane is concerned. The completion of any lift is dependent upon the one giving the initial instructions.

D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Corp.,
Pittsburgh, Pa.

What will you be doing ten years from now?

FOR a number of years I have watched certain men grow out of small jobs into big ones with better salaries and larger responsibilities. Some of these men I have employed in their younger days, and others were acquaintances in whom I have been interested. What I want to tell you here is not why some men with a so-called pull succeed, but why every normal man with energy and ambition and an average brain can eventually grow into the position he would like to hold.

FIRST, it seems to me, as I have observed the progress of men who have accomplished things, that the *ego* in human nature must be suppressed. If you know you can handle a job, don't brag about it—just go ahead and do it and repeat the doing until the job itself and the way it is done will stand out as a particular characteristic of yourself. Next, don't be afraid to take on new responsibilities or new jobs. I always remember a remark by an old boss of mine after I had devised a new method that would save him time and money on a particular job. The method was good and he liked it, but it was developed too late to make full use of it. A considerable amount of stock already purchased would have had to be discarded to make the saving by the new method. This he explained to me with the comment: "We don't mind spending money on the idea of a live one if he can keep us from stumbling over the mistakes of the dead ones."

IN OTHER words, routine methods in a large plant need new and fresh thinking now and then, and the man who is closest to the routine is the one who has the chance to correct the mistakes of others and devise better methods of his own.

TODAY many machines that would normally last twenty years before being worn out are profitably discarded in half that time for more expensive machines, because of the kind of work they will do. And so it is with men who are given charge of a particular department or group of men and machines. I have collected several instances in plant work where operators have used their heads as managers as well as operators. For example, a plant engineer recently found that an electric hoist and one man would replace eight men and prevent considerable damage to the materials handled; so the hoist was installed. The general superintendent of a machine works by installing eighteen lift trucks and special platforms reduced the handling gang by fourteen men, with a total saving of $14,000 in handling costs the first year. A plant electrician, by getting the management to install pressure lubrication fittings on all bearings of motors and fans, reduced the cost of lubrication over 75 per cent and has not had a single case of bearing trouble in more than a year, whereas such troubles were formerly common causes of shutdowns.

IN ANOTHER plant, the chief electrician has demonstrated that push-button magnetic starters for motors have saved many times their cost in causing operators to shut off their machines when not in use, because the push buttons located on the machines make it easy for the operator to do this. Besides, the push buttons have saved much production time by preventing the running back and forth formerly required to operate hand starters mounted near the motors.

IN A recent issue of *The American Magazine,* there appeared an inspiring interview with Mr. Lawrence A. Downs, now president of the Illinois Central Railroad, who is the son of a section foreman of that road. Mr. Downs says he is simply an average person who has done things the ordinary man does, and about average well. But he has always kept his eye on a promotion and prepared himself to fill it. That has been the important thing in his life. These, according to Mr. Downs, are the seven essentials to regular promotion:

1. Do your stuff on the job you now have.
2. Let your boss know that you are dependable.
3. Avoid pockets and blind alleys, even if you have to quit a job.
4. Size up the job ahead of you and prepare yourself for it.
5. Don't overwork, but plan your work and don't waste time.
6. Don't over specialize, but balance up your accomplishments so that you can do several things well.
7. Be fair to yourself, your employer, and your associates.

IF YOU are wondering what you will be doing five or ten years from now, Mr. Downs' advice may make it possible for you to work out a very satisfactory answer to that interesting question.

Practical Pete

INDUSTRIAL ENGINEERING

Application and Operation of Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

Published by McGraw-Hill Publishing Company, Inc.

G. A. VAN BRUNT, *Editor*

New York, September, 1927

We Have Changed Our Name

WITH this issue INDUSTRIAL ENGINEER changes its name to INDUSTRIAL ENGINEERING. The change is slight—merely the addition of three letters—but the new name expresses more exactly the field and scope of this publication. Its purpose is to present and to discuss from a practical standpoint the operating and engineering problems met with in the selection, installation, operation and maintenance of electrical and mechanical power drive equipment, and the equipment for furnishing such important plant services as lighting, material handling, heating and air conditioning, fire protection, and signaling and communication.

There will be no change in editorial policy beyond a broadening of the range of subjects treated that will enable us to serve more completely the industrial plant operating executive in all his various responsibilities.

Readers of INDUSTRIAL ENGINEERING are invited to submit the details of their operating problems to the editors for discussion and help, and to send in suggestions concerning the kinds of information that would be helpful to them.

A Statesman of Industry

WITH the passing of Elbert H. Gary, chairman of the board of the United States Steel Corporation, there was removed from the ranks of the great industrial leaders one of the most outstanding figures of this generation. Invested with tremendous power, as the head of the greatest industrial organization in this country, Judge Gary used this power with a wisdom, vision, and sense of responsibility that almost overshadowed his exceptional business judgment and genius for organization. The intelligence and character that won for him his victory over tradition developed into leadership that kept the industry free from internal strife and thus free to grow strong in public favor. As expressed by President Coolidge in his message of sympathy, "He stood foremost among those who find in the great private enterprises of our country an opportunity for public service as well as a medium for financial profit."

In truth, the outstanding achievements of the man were not the organization and eminently successful management of the great industrial enterprises which he conceived, but the fact that he used the power which his position gave him to put American business on a higher plane of service and conduct. Recognition of this fact was the keynote of the eulogistic messages, "He did most to restore conscience to business." "He led in the great movement to elevate industry to its present high plane of business and social morality and justice." "He stood for fair competition—he was the statesman of business," that came in a flood from the heads of business and industry.

To Judge Gary there came great power and with it almost boundless opportunities for service, both to the public and to industry. The constructive manner in which he used these opportunities won for him the admiration and affection of his associates, and a unique place in the annals of American business.

Check Up on the Location of Your Plant Service Departments

FREQUENTLY the men in charge of maintenance and other plant work fail to realize the advantages of a well-selected location for their headquarters. An inconvenient location not only wastes the time of the men in the department, but delays them in responding to trouble calls. The following incident shows the possible extent of this loss and also illustrates a method that other men can use to secure better locations for their departments.

In one plant two shops providing maintenance service were located in different corners of the plant yard at a considerable distance from each other, and about as far as they could be placed from the busiest sections of the plant, which naturally require the most service. In order to obtain a better location the head of the department kept a daily record for a week of the number of trips the men made between the shops and the various departments and determined the average distance for these trips. A similar estimate was made of the distance that would be traveled, assuming the men had responded from the desired location in the center of plant activity. It was thus found that the equivalent of two men's time was spent in absolutely unnecessary walking.

With these data the head of the maintenance department easily proved to his superior the advantage of moving his department to the new location. After making the change it was found that the force could be reduced by one man. Furthermore, supervision was easier, the men in the two departments co-operated better, a single storeroom was able to serve both shops, and a number of other economies were effected that in the aggregate made a worth-while saving.

Doubtless many other plants could with profit analyze the source of their trouble calls to determine whether more suitable locations, from the standpoint of convenience, could be found for their service departments.

Pushing Back the Limits of the Impossible

RECENT perfection by the American Rolling Mill Co. of a continuous rolling process for making thin sheets from ingots is one of the most interesting developments that has been made along this line for many years. It is also a good example of the fact that traditional methods are not always the best or most efficient, even though they may have been hallowed by years of use.

Until the present development few changes of consequence had been made in the process of rolling sheet, since the conventional method was worked out about 1750. Nor was it a simple matter to improve this process. A good many years of experiment and the expenditure of huge sums of money were required to bring the new process to its present form. Extensive research was necessary on the fundamental factors involved in rolling sheets, and many problems had to be solved before all of the details of the method could be worked out. Nevertheless, determination, backed by skillfully directed hard work, finally brought success, and the new process stands as a monument to all who played a part in its development.

Satisfaction with present achievements, whether these be personal or relate to the methods employed by an industry, may be a pleasurable indulgence, but it will never lead to lower production or operating costs. There is probably no method or piece of equipment used in an industrial plant that cannot, or will not, be radically improved within a comparatively few years. Pushing back "the limits of the impossible" is not an easy task, but that it can be done is being clearly demonstrated every day.

Let Your Lighting System Help to Cut Production Costs

WHEN artificial lighting is considered by plant operators on the same basis as other items of equipment used in production, the unit cost of the product is bound to be affected. In many plants there is at this time of the year a pronounced slowing up of production during the last half of the day. The reason for this will be found not alone in the physical exhaustion of the workers, but in the shorter period of daylight and the lack of efficient artificial lighting.

While there is time before operations must be carried on by lamp light in the early morning as well as the late afternoon hours, advantage should be taken of this opportunity to make any necessary changes or additions to the lighting system in preparation for the fall and winter production peaks.

If this has not already been done, it will be highly advisable to make a lighting survey of the plant. That is, the intensity of illumination at the working plane should be measured around machines and benches, as well as in stairways, storerooms and like places, to determine whether it is up to the standards that have been recommended as good practice. Such a survey is not difficult to make and it is almost certain to give some interesting results.

Needless waste of time could often be eliminated if the work were properly lighted, for one correct micrometer reading is worth a dozen guesses in the dark. The savings in the cost of material alone that is spoiled due to poor lighting may well equal the cost of improved lighting. Furthermore, in a well-lighted plant there is less danger of injury and fewer accidents, which is reflected in lower insurance rates, where compensation laws are in effect. Safety signs or posters are of no use if there is insufficient light to read the "Cautions" and the "Don'ts."

No plant operator can afford to ignore the fact that good lighting is a dividend-paying tool, as well as an effective form of protection against high production costs.

Every Employee Shares Responsibility for Fire Protection

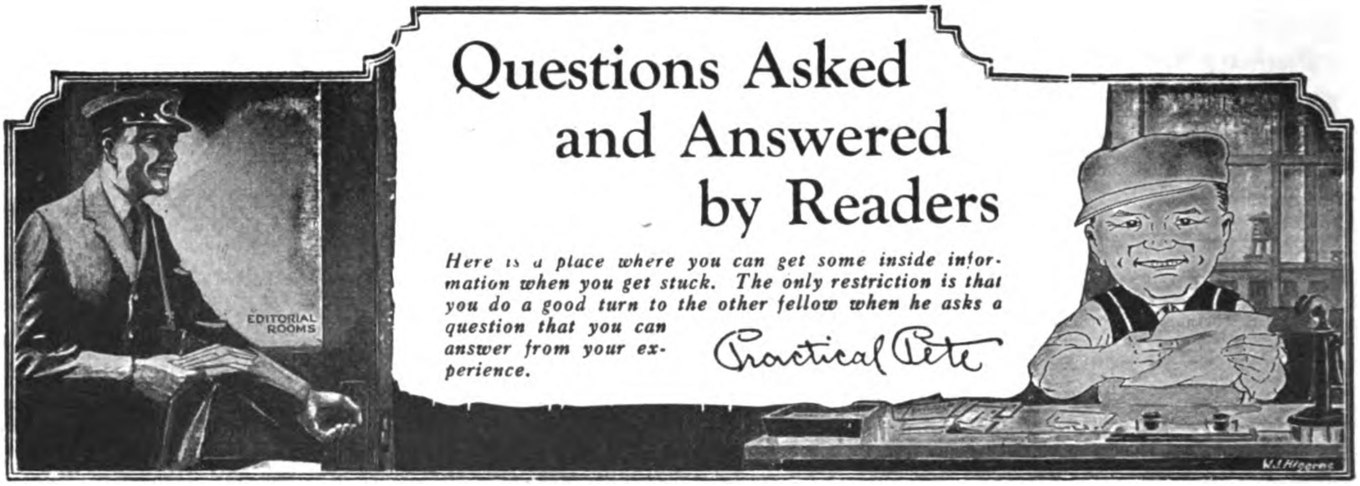
THE importance of adequate fire protection to the men employed in an industrial plant is well illustrated by the fire record of New York City for one month. During that period, as a result of 71 fires, 24 of the concerns affected failed, and a still larger number did not resume business.

Fire is one of the most serious hazards to industry because insurance ordinarily covers only the actual loss to property and does not compensate for interruptions to operation, delayed deliveries, or lost customers. Insurance never covers the lost time or the lost job of the worker.

The responsibility for fire protection rests upon the management of the company, but the workers are largely responsible for fire prevention. The management should provide adequate firefighting equipment, train the men in its use, and see that it is maintained in condition for instant service when the emergency comes.

The workers should co-operate by giving careful attention to good plant housekeeping, by compliance with no-smoking and other fire rules, by learning the hazards of the processes employed, by becoming familiar with the use of the firefighting equipment that is provided, and by learning what to do and what not to do when a fire suddenly breaks out.

In case of a fire both the workers and the management lose; therefore both must work together to prevent its occurrence. The men responsible for plant operation can do much to foster this co-operation. Furthermore, because of their familiarity with plant conditions they can and should suggest both means and methods of protection and prevention.



QUESTIONS

Who Can Answer These?

Slippage With V-Belt Drives

I should like to have readers tell me what their experience has been with parallel V-belt drives, using rubber fabric belts on short centers. What is the difference between their operating characteristics and those of a rope drive? Can you give me any information on the coefficient of friction and minimum arc of contact? I understand that these belts tend to creep and have no slip. What happens when one or two of the belts stretch? I shall be gratified for any information you can give me.
East Pittsburgh, Pa. H. G.

Fastening Rotor Bars to End Rings

The heating of the rotor in one of our squirrel-cage induction motors during the starting period affects the soldered connections between the bars and the rings enough to make it necessary to resolder these connections about every 6 mo. Will readers tell me how to solder or secure the bars permanently to the rings so as to eliminate further trouble with them? If silver solder, or some other kind, is employed, I should like to know what flux to use, together with any suggestions you can give me on how to do the job.
St. Marys, Ont., Can. W. E.

Preparing Insulated Pipe For Painting

We are planning on painting our pipe lines but find that the covering on the insulated lines absorbs so much paint that several coats are required to cover it. I wish that other readers would tell me what they have used as a first coat of size to make such surfaces nonabsorptive.
Rock Island, Ill. R. M.

Cause of Excessive Arcing at Motor Brushes

The brushes of the hoist motor, on our 15-ton crane, arc excessively. This is a 20-hp., 220-volt, 1,030-r.p.m., 80-amp., series-wound, d.c. motor with four interpoles and I am wondering if the trouble is due to the fact that it is operated from a 245-volt line. Although we have tried various kinds of brushes and have tested both the armature and field coils, excessive sparking persists after the resistance is cut out of the armature circuit by the controller, when either raising or lowering loads. I shall appreciate any information from readers that will help me to stop the arcing.
St. Louis, Mo. H. E. A.

Layout of Belt Drive for Waterwheel-Driven Generator

We are installing a 400-r.p.m. waterwheel to drive a 1,200-r.p.m., 100-hp. generator. The plans call for a drive pulley 60 in. in diameter with its center less than 10 ft. from the center of the 20-in. generator pulley. Both pulleys are 10 in. wide. We now have the pulley for the generator, but not for the waterwheel. Will readers please tell me (1) the minimum distance between pulley centers that could be used for this drive. (2) What width and thickness of belt should be used? (3) What kind or type of belt tightener should be used? (4) If the belt speed will be too high with the pulleys mentioned above, what sizes of pulleys can be used to drive the generator at the proper speed?
Allende, Coah., Mexico. L. N. S.

Safe Operating Temperatures For Magnet Coils

In view of our operating conditions I shall appreciate it if readers will let me know what they consider to be the maximum safe continuous operating temperatures for lifting magnet and magnetic clutch coils would with (1) single-cotton-covered enameled wire and (2) single cotton and asbestos covered wire, both with and without varnish treatment.
Ansonia, Conn. A. E. B.

How Does Change in Frequency Affect Transformer?

I should like to make use of some 60-cycle transformers on a 25-cycle circuit and shall appreciate it if readers will answer the following questions: To what extent will the change in frequency affect the output capacity, over-all efficiency and operating temperature of the transformers? Would thicker laminations increase the efficiency?
Muskogee, Okla. M. A. S.

ANSWERS

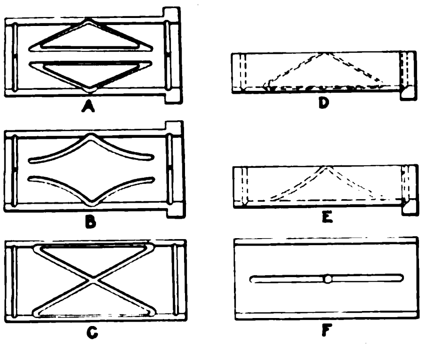
Received to Questions Asked

Oil Grooves in Bronze and Babbitt Bearings

We rebuild our bearings and I wish that readers would tell me the best form of grooves to cut in oil-lubricated bronze and babbitt bearings up to 3-in. bore, for shaft speeds of about 300 to 1,800 r.p.m. I should like to know how grooves should be cut in both solid and split bearings. When should straight and when should criss-cross grooves be used? How wide and how deep should grooves be cut? How should grooves be cut for grease lubrication?
Scranton, Pa. B. V. W.

ANSWERING B.V.W.'s question, the function of channels cut in bearings is to convey the lubricant in sufficient quantity to the place where it is most needed.

A sleeve bearing will carry heavy loads at low and medium speeds with ordinary lubrication, such as rings or chains. According to the fancy of the mechanic who is cutting them, oil grooves may take many forms, some of which are shown in the accompanying illustration. The bearings shown at *A*, *B* and *C* represent three different types of grooves employed for oil lubrication. The bearing at *D* shows a babbitt-lined split-iron shell with a chamfered edge, which indicates the bottom half of the bearing. A bearing with a single goove cut in the bottom is best adapted for grease lubrication and this type is shown at *F*. I believe that the groove for oil lubrication should be about $\frac{1}{3}$ the thickness of the bearing wall, and must not have any sharp edges to cut the oil from the shaft. In a babbitt-lined bearing the width of the groove should about equal the thickness of the babbitt wall. The bearing should then be chamfered where the oil ring discharges to the oil groove, providing a small reservoir for the channels to draw from. At the ends of the bearings a drainage channel should be cut at right angles to the length. One or



This shows several different types of grooves used in sleeve bearings.

more circular grooves are cut in the end of the bearing and each of these should have a small hole at the lower side to drain out the oil.

Drainage canals must be cut in the bearings of electrical machinery in order to prevent the oil from reaching the windings. These drainage canals are usually cut from 3/8 to 1/16 in. from the end of the bearings. The oil grooves must not be set closer than 3/8 in. to the drainage groove, or the oil will run directly to the reservoir. In small bearings such as at *E*, one groove at each end of the bearing will be sufficient.

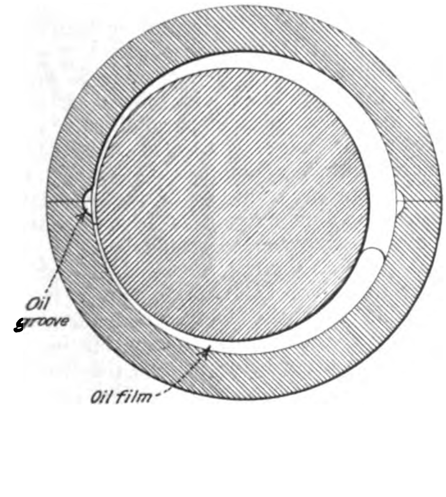
A gouge may be used for cutting these grooves, but an old, round file ground to the proper shape makes an inexpensive tool for this purpose.

A combination of rings and pressure lubrication is often used for speeds from 3,000 to 3,600 r.p.m. but the heavier machines are supplied with a separate oiling apparatus which is started before the machine. The lubricant is supplied under pressure to the bearings, so that ordinary slots are needed as oil channels.

Birmingham, Ala. GRADY H. EMERSON.

REFERRING to the question by B.V.W., there seems to be almost as many opinions and practices in cutting oil grooves as there are designers. The General Electric Company's method as applied to motor and turbine bearings seems to me to be a very good one.

This shows the approximate shape of the oil film in the lower part of a bearing.



For ring-oiled bearings, a longitudinal oil groove is cut along each side of the bearing, whether solid or split, on the horizontal axis, as shown in the illustration. These oil grooves are extended into the oil-ring slots of the upper half of the bearing and go to within 1/4 in. to 1/2 in. of the end of the bearing or of the circumferential oil-collecting grooves usual in motor bearings. The longitudinal grooves are made about 1/4 in. wide and 1/8 in. deep on bearings that are 1 in. to 1 1/4 in. in diameter, and the dimensions of the grooves are increased to about 1 in. wide and 1/2 in. deep on bearings that are about 4 in. in diameter. These grooves should be flared out and have the edges rounded, as a sharp edge will tend to scrape the oil off the shaft. The rounded edges also facilitate the feeding of the oil to the bearing. Ordinarily an oil ring is needed for each 6 in. of bearing length.

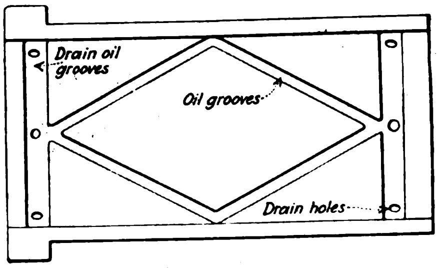
The arrangement of grooves for forced oil feed bearings in turbines is similar to that in motor bearings, a groove being located just below the split of the bearing on the side where the shaft runs down into the bottom half. The oil supply pipe is also connected at this point.

A general idea of the behavior of lubricant in a bearing may be determined from tests that have been made, which show that as the shaft turns the oil is drawn into the bearing and forms a wedge-shaped film under the shaft. The shaft is separated slightly from the surface of the bearing, the pressure on the bearing being greatest opposite the point of resultant pressure of the shaft. If grooves are located in this part of the bearing, they will relieve the pressure of oil formed under the bearings and consquently the lubricant will be allowed to flow out of the bearing instead of being kept where it is most needed. Therefore, it is evident that the real source of oil supply is due to the pumping action of the shaft pulling it into the bottom of the bearing. This action of the shaft on the oil may be considered to be the principle by which location of oil grooves is determined.

If for any special reason it is necessary to use grease in a bearing, the grooves along the top of the bearing should ordinarily be cut about twice the size of those recommended for use with oil. A compression grease cup or some other means of obtaining a steady flow of lubricant should be employed.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

REFERRING to the question asked by B.V.W., there is a tendency among many mechanics to cut too many oil grooves in a bearing, on the assumption that the more grooves there are, the more lubrication the bearing receives and the less likely it is to heat. Actually, grooving should be done with the utmost economy in order to retain as much as possible of the bearing surface. Too many oil



This shows one way of cutting oil grooves in a bearing.

grooves cut in a bearing not only cause a reduction in the surface area, but the bearing is weakened.

The oil groove edges should be rounded off; otherwise the sharp edges are likely to wipe off the oil, and cause the bearing to heat. After a bearing has been used for some time it should be examined to see whether the wear on the babbitt has sharpened the edges of the grooves or closed them.

The accompanying illustration shows where to locate drain grooves and drain holes. The holes should be drilled in the lower portion of the drain grooves. These holes and grooves permit the oil to flow back into the oil well.

H. J. ACHEE.

District Line Supt.,
Southwestern Light & Power Co.
Elk City, Okla.

IN ANSWER to B. V. W.'s question, the surface speed of the shaft, load, and the length of the journal are the main factors that determine the cutting of oil grooves. On no account should oil grooves be cut too wide or deep, because wide oil grooves reduce the surface of the bearing, which may result in overloading. They should not be more than 3/32 in. wide or 3/32 in. deep as a rule, but these dimensions will need modifying according to the circumstances. Complicated oil grooves should be avoided, for in many cases

This shows method of lubricating bearings by cutting circular groove as in Fig. 1, and chamfering, as indicated in Fig. 2.

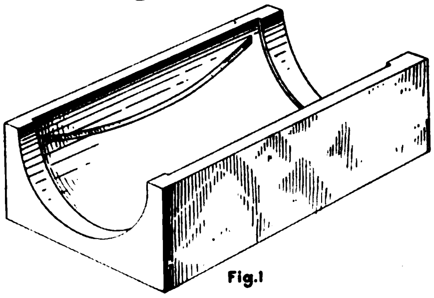


Fig.1

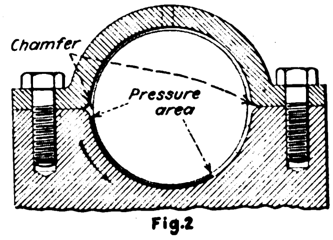


Fig.2

the grooves serve only to carry the oil from where it is needed and consequently reduce the bearing surface area. Bearings designed for slow-speed shafts always require oil grooves, whereas in high-speed bearings centrifugal force tends to carry the oil around the shaft; so grooving is not quite so important. To my knowledge the oil groove that has given the greatest satisfaction in practice is a curved groove, as shown at Fig. 1 in the illustration cut nearly to the ends of the bearings, or a curved groove which is joined by a straight groove. Spiral grooves have been employed for very long and small bearings. Oil grooves usually are cut only in the top half of the bearing where the oil is introduced but grooves may be cut in the bottom half so as to collect the lubricant and return it to be used again. Such grooves are seldom used, for if incorrectly cut they serve only to drain the oil from where it is needed.

For grease lubrication, grooves must be used, as grease has insufficient viscosity to work along the shaft under any conditions. A plain curved groove should be satisfactory. There is not much difference in grooves either for split or whole bearings, but it is essential that the edges of the groove be well rounded off so as to give a wedge-shaped entrance for the lubricant to the pressure area. The direction in which pressure is exerted as indicated in the illustration must be considered as the grooves should be located so as to introduce the lubricant to the shaft surface just before the pressure area is approached, as shown in Fig. 2 in the illustration.

In some instances chamfering, which consists of cutting away the edges of each bearing segment, gives better results than oil grooves. This provides a small, wedge-shaped lubricant reservoir which extends to within half an inch of the radius at each end of the bearing, as shown in Fig. 2. In many cases, no grooves other than chamfering are required, especially where the pressure is upwards. When the shaft oscillates or rocks, chamfering, which can be done only with split bearings, usually gives the best results. Criss-cross grooves may be necessary under special conditions, but to my knowledge and experience the groove shown in Fig. 1 has always given satisfaction, and can be used for most purposes in an industrial plant.

W. E. WARNER.
Shefford, Bedfordshire, England.

Trouble With Squirrel-Cage Motor

On a dust collector in our cement plant we recently had occasion to replace a 5-hp. motor with a very old 10-hp. motor that had been standing in our store-room for some little time. We desired to speed up the fan of a dust collector and thought that this motor would do it inasmuch as it was rated at 850 r.p.m., 13 amp., 10 hp., 440 volts three-phase. After installing the motor and starting it, the resulting speed on the motor was only 250 r.p.m. while the current per phase was 8½ amp. After taking the belt off the motor and dust collector and letting the motor run idle the speed went up to 770 r.p.m. while the current decreased to 6 amp. per phase. I have never seen a squirrel-cage motor behave quite in this manner and cannot understand how the speed can drop as low as 250 r.p.m. without the load current going up to even normal rating. There was no sign of heating no matter how long the motor ran. It occurred to me that possibly some one had tampered with the coil connections so I opened up the motor and found the stator to be connected single circuit star. Can any reader suggest why this motor behaved in this manner?

Detroit, Mich. R. W. B.

ANSWERING R.W.B.'s inquiry, I believe that the trouble he mentions is probably due to a defective squirrel-cage rotor. If the bars and end rings are carefully examined, loose or broken joints will probably be found; or if the rotor is of the soldered type, it may be found that most of the solder has been thrown out of the rotor joints.

In any event, if this rotor is defective it can be put into perfect condition by welding with an acetylene torch, using a good grade of cold-drawn bronze welding rod.

R. K. HOKE.
Manager,
Keystone Electric Co.,
Baltimore, Md.

IN ANSWER to R. W. B.'s question, consider the operation of an induction motor provided with a phase-wound rotor. This motor is started by the application of the normal operating voltage to the stator winding. Then the resistance, which is connected in series with the rotor winding through the slip rings, is varied until the motor starts up.

The motor will accelerate until it reaches a certain definite speed. It will run at this speed as long as this resistance is kept constant. Now, if a load is put on the motor, the motor speed will drop. The more load the motor is called upon to carry the greater will be the drop in speed. If it is desired to increase the speed of the motor at a certain definite load, it will be necessary to cut out more of the rotor resistance. If it is desired to obtain the maximum speed for a particular load it is only necessary to cut out the entire rotor external resistance. When this condition obtains, the motor will behave exactly the same as a squirrel-cage induction motor.

As R. W. B. states that the stator winding is properly connected, the misbehavior of the motor is due to a defective rotor. The resistance of the rotor winding of a squirrel-cage induction motor is fixed. The value of this resistance can be varied only during the process of manufacture or by extensive alterations.

As a matter of fact, the characteristics of a given machine can be changed markedly by providing it with rotors having different kinds of end rings. For instance, if the machine be provided with a low-resistance rotor, its slip will be low, its starting torque poor, and it will have a high starting current and a high pull-out torque. If the machine is fitted with a high-resistance rotor, the slip will be high, it will have a high starting torque, a low starting current, and a low pull-out torque.

The end rings are either bolted, welded or soldered to the rotor bars. The very best of workmanship is required in order to attach the end rings to the rotor bars, whatever the method, so as to obtain the proper resistance and avoid a poor contact between the rotor bars and rings. It is quite possible that due to unusual operating conditions, for instance, subjecting the motor to undue overloads for long periods of time, or to repeated starting under abnormal conditions, the rotor rings of a well-built motor may make a poor contact with the bars due to uneven expansion, melting of solder, or any other cause that would tend to increase the resistance.

That R. W. B.'s motor has a rotor with high contact resistance between bars and end rings is indicated by the fact that even at no load the speed is below what it ought to be, were the rotor in good condition. I am confident that if he will solder or weld the rotor so as to make good contact between the bars and end rings, he will find that the motor will operate satisfactorily.

HENRY SCHERIL.
Brooklyn, N. Y.

IN REPLY to R.W.B.'s question, it would be advisable for him to check the size of the wire in the stator winding and then determine the proper connection. It is apparent, however, that the slip is excessive as the no-load speed should be approximately 900 r.p.m. if the frequency is 60 cycles, and the full-load speed should be about 850 r.p.m., according to the nameplate rating. Probably the reason for this excessive slip is that there are too many turns of a given size of wire in series and at 440 volts it is impossible to force enough current through the coils, due to the combined effect of resistance and reactance, even though the counter emf. is very low.

Therefore, it would be advisable to check the size of wire first in order to determine the proper connection. As it is stated that the motor is connected single-circuit star, and as the line current flows through each leg of the winding with this connection, the size of wire should be approximately 750×13 or 9,750 circ.mil or between Nos. 10 and 11 B. & S. gage.

However, if the size of wire is one-half this or 4,875 circ.mil, then the connection should be parallel star. If the stator were connected delta, the current per leg should be $13 \div 1.73$ or 7.51 amp. in each leg of the winding when the line current is 13 amp., and the wire size needed would be $7.51 \times 750 = 5{,}630$ circ.mil, which is quite near to a No. 12 B. & S. wire. It is possible that the winder intended to connect the machine this way, but made the error after bringing out the three-phase ends.

As R. W. B. did not designate the size of wire used, or number of slots, it would not be possible to state the proper connection accurately without going into the subject of design, but he could make a Prony brake test on the machine and determine the proper connection very accurately.

If when starting with a delta connection the speed falls below 850 r.p.m. at a 10-hp. output, and the current is below 13 amp., or if the starting torque is low, change to a parallel star connection. If this is unsatisfactory, then go to a parallel delta, and so on, until an output of 10 hp. and 850 r.p.m. is obtained with 13 amp. per phase at 440 volts.

In the above it is assumed that the frequency, voltage, coil pitch and the like are correct and the figure 750 is taken as the circular mils per ampere, although this figure may vary as much as 20 per cent.

Ordinarily in cases where there is sufficient time it is usually best to ask the manufacturer for complete winding data and check the machine from the designer's record. F. H. Rooney.

Chief Electrician,
Columbia Steel Corporation,
Provo, Utah.

Changing Speed of Electric Drill

I have an electric drill that I wish to use for other purposes which will require a lower speed. The nameplate is missing, but the present no-load speed is about 1,800 r.p.m. and the full-load speed 1,200 r.p.m. The drill is driven by a universal motor and is capable of boring a ¼-in. hole in steel when operating from a 110-volt, a.c. circuit. Will some reader please tell me how I can reduce the motor speed to one-half or three-quarters of its present value? What is the principle involved in increasing or decreasing the speed of a universal motor?
Moline, Ill. J. M. M.

Answering J. M. M.'s question, he will have considerable difficulty in trying to decrease the speed of the drill and still maintain the same horsepower, unless the motor is rewound. I do not believe this procedure would be warranted, if the drill is to be used for ordinary purposes.

On the other hand, the speed can be decreased by cutting resistance in the motor circuit. This method, of course, is not very practical from an economy standpoint. Even if this were done, the speed of the motor would not be decreased until a load was put on it.

Troy, N. Y. J. M. Peterson.

Answering the question by J. M. M., the speed of a series motor varies with the load and applied voltage. In this case full load reduces the speed of the electric drill, which operates on a 110-volt, 60-cycle single-phase circuit, from 1,800 r.p.m. at no load to about 1,200 r.p.m. at full load.

In order to reduce the speed of the drill further a resistance at suitable current capacity can be inserted in series with the motor. Although this method reduces the voltage at the motor terminals, it also reduces the power developed. Consequently, to operate the motor at the desired speed and still keep the load safe within safe working limits, the load on the motor must be reduced considerably as the speed is reduced.

H. S. Ramsay.

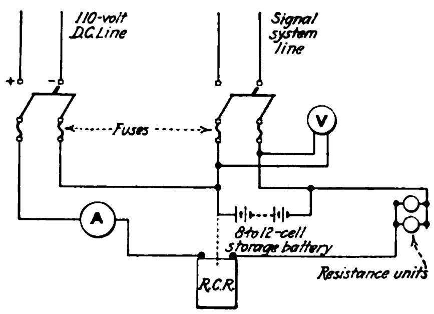
East Kingston, N. H.

Reducing D. C. Voltage

Current for operating our signal systems is now supplied by two motor-generator sets; the demand on the generators varies from 15 to 20 amp. at 15 to 20 volts. We wish to discard our motor-generator sets and I should like to know of some suitable method of reducing the voltage on our 110-volt, d.c. service line so that we can operate our signal systems from it. It has occurred to me that a water rheostat might be suitable for this purpose. If so, can some of the readers give me the data for such a rheostat? Can anyone suggest a better method?
Chicago, Ill. M. G

Two methods will be suggested, in answer to M. G.'s question, in view of the fact that many signal systems operate intermittently in which case the actual number of ampere-hours consumed in 24 hr. is small. Also, reliability and freedom from power shutdowns are important considerations.

My first suggestion involves the use



This shows how a storage battery that floats on the line should be connected to a signal system.

of an 8- or 12-cell, lead-plate, glass-jar, storage battery, or 12 Edison nickel-steel cells, which should be connected to the signal system as indicated in the accompanying diagram. The ampere-hour capacity of this battery should be equal to the signal system's demand over a 24-hr. period plus 20 per cent of this demand.

In this case the number of ampere-hours needed per day will, of course, govern the type of battery charger, which may range from a simple d.c. trickle-charger as used in radio work to a Ward Leonard resistance unit, or a lampbank in series with a double-pole switch and the battery. These chargers should be connected to the system at the point in diagram marked *resistance units*.

M. G. will find that the use of a reverse-current circuit breaker would be advisable, as it would prevent the discharge of the battery into the line in case of power failure, although it is not absolutely essential. If such protection is desired, it might be well to investigate a device made by the Fansteel Products Co., which is designed to serve the purpose of a reverse-current relay. If a relay is used it should be connected at the point marked *R. C. R.* in the diagram.

The amount of charge in 24 hr. should equal the amount of current used plus 15 to 20 per cent. The batteries should float on the line, holding the signal system voltage steady in addition to taking care of demands that are in excess of the charging current. When the demand from the signal system has ceased, or is low enough, the storage battery will absorb current from the 110-volt line.

All cells in the battery installation should be in series and the terminals should be connected positive to negative. Assuming that the negative side of the 110-volt d.c. circuit is grounded, the negative leg should be connected through 30- to 60-amp. fuses to the signal lines and system.

All battery connections should be scraped clean and bright before connecting, after which they should have a liberal application of cup grease or vaseline to prevent corrosion of the brass bolts and nuts or steel bolts and nuts if Edison cells are used. The cells should be placed in trays filled with sand or upon slate, glass or marble slabs that are insulated from the ground to avoid leakage of current.

A hydrometer or voltmeter check should be kept on the batteries to determine whether they are fully charged, or over- or under-charged. These checks will in turn enable the charge to be kept down to the minimum value necessary to keep the battery fully charged.

The above system, as outlined, is generally very satisfactory, dependable and economical, and the storage battery, if not overcharged more than twice a month or allowed to remain discharged for any length of time, ought to render 5 to 10 yr. of service.

There are certain precautions regarding the case of storage batteries that must be observed; namely, keep the water at the proper level; keep flames and sparks away from the cells; once a month pull the line switch for 12 to 24 hr. to discharge the battery; once a month, when no load is on the system as on a Sunday or holiday, step up the charging rate and overcharge the battery for a couple of hours.

A storage battery is much preferable to a water rheostat, which does not make a very satisfactory permanent installation, especially for this type of work. A. Fiess.

Tampa, Fla.

In reply to M. G.'s question, I would not recommend the use of a water rheostat to step down the line voltage for the service, as suggested in the question.

On the other hand, I would recommend stepping down the line voltage of the 110-volt circuit by the use of counter-electromotive force cells, which

would be the most economical and practical for this service in the long run. The cells are made of lead composition grid plates that contain no active material. These plates are immersed in a solution of sulphuric acid of 1,210 sp.gr. at 70 deg. F.

The cells that I am most familiar with are manufactured by the Electric Storage Battery Co. of Philadelphia, Pa., and are known as the Type ET couple grids.

In this case as these cells are connected in series with the load and line current and the voltage of each cell is two volts, it will be necessary to use 45 cells, thus reducing the operating voltage of the circuit of the signal system to about 25 volts. The cells can be cut into the circuit on either the positive or negative side of the line. It must be remembered, however, that as the water in the cells evaporates it must be replaced from time to time and especially when the circuit is used quite frequently.

When the cells are first cut into service, it will be found that the voltage at the terminals of the signal system will not be lower than the line voltage, but after a very short time, the voltage will drop to the required 25 volts and after that the operating voltage will remain constant. In my opinion this is the most practical and economical method of solving the problem described in the question.

F. J. H. KRAUSE.
Dallas, Texas.

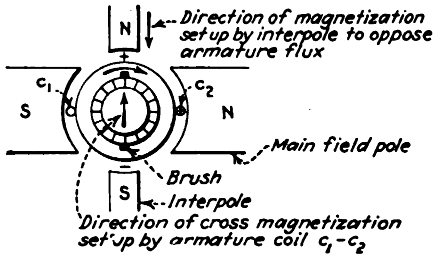
Polarity of Interpoles

I do not thoroughly understand the rule governing the polarity of interpoles and wish someone would explain how it works out under different conditions. For example, on machines that have two interpoles, I have often found them to be of opposite polarity. Was this polarity correct? Can one rule be made to apply to a motor having any given number of main poles and interpoles? I shall be grateful for your help on this question.
Mohiland, Utah. K. W. F.

AN ANSWER to the question by K. W. F. can be more clearly understood by referring to the accompanying diagram, which shows the proper polarity for a two-pole generator. It should be noted that the interpoles in this case are of opposite polarity. The reason for this may be determined by noting the direction of the flow of current in the armature coil, which for simplicity is shown as one turn.

The current flowing through the coil produces a magnetic effect, which is neutralized by an equal and opposite magnetic effect produced by the interpoles whose coils are connected in series with the armature, and the magnetic section so proportioned that the field set-up practically varies directly in value with the armature current. It should be noted that the preceding interpole is of the same polarity as the main pole.

K. W. F. can clear up the question in his mind further by dividing a circle into any equal number of parts and assuming them to be main poles. Then by applying the rule that in a generator for a particular direction of rotation an interpole of the same polarity precedes the main pole, it will be seen by inserting the correct interpoles that those diametrically opposite will always be of the same polarity, the only exception being in the case of a two-pole machine. Here the diametrically opposite poles are of opposite polarity.



This shows the relation between the polarities of the main poles and the interpoles in a two-pole machine for clock-wise rotation.

For a motor, an interpole has the same polarity as the main pole it follows, assuming, of course, the same direction of rotation.

C. OTTO VON DANNENBERG.
Electrical Division,
General Engineering & Management Corp.
New York, N. Y.

REFERRING to K. W. F.'s question, the object of using interpoles on direct-current generators and motors is two-fold. First, to improve commutation by eliminating sparking due to changes in load and second, to accomplish this effect automatically rather than manually, which is the case with non-interpole machines in which the brushes must be shifted as the load is varied.

The interpole winding is made up of a few turns of heavy copper and is conected in series with the armature. As in the case of machines with series windings, the strength of the interpoles is adjusted by means of a shunt, which diverts a portion of the armature current, in case the interpoles are too strong.

In direct-current generators or motors provided with interpoles, if the armature has a multiple-circuit winding there are as many interpoles as there are main poles or brush arms. If the armature has a two-circuit winding, in which case only two sets of brush arms are used, only two interpoles are required. A railway motor is a good illustration. The armature has a two-circuit winding; and the motor may have four main poles, two sets of brushes and only two interpoles.

Although the machine is provided with only two interpoles, they must be of unlike polarity. This must necessarily be so, because the windings of the interpoles are so connected that the currents in the two interpole windings flow in opposite directions, thus producing a north interpole and a south interpole. Furthermore, the magnetic circuit is made from one interpole to the other and that can be accomplished only when the two interpoles are of opposite polarity.

The general rule for the polarity of interpoles is as follows: Assume clockwise rotation. Then, for a generator, the interpole next preceding the main pole is the same polarity as the main pole; for a motor the interpole next preceding the main pole is of opposite polarity to the main pole. In other words, in a generator, a main north pole will precede a north interpole and in a motor a main north pole will precede a south interpole.

HENRY SCHERIL.
Brooklyn, N. Y.

Installing Anti-Friction Bearings in Sleeve-Bearing Motors

We have a large number of induction motors of modern design, ranging from 10 to 75 hp. in size, that are fitted with ordinary sleeve bearings. Many of these motors operate in a very dusty place and considerable trouble has been experienced from rapid bearing wear. On all of our motors we have had trouble with oil slinging, which has caused a number of failures. For these reasons we are considering installing ball or roller bearings. Accordingly, I shall appreciate it if readers will tell me (1) their experience with these bearings and (2) give me some information on how to install them in place of the present babbitted sleeve bearings. (3) Can you give me any data on the cost of making such a change? L. M.
Joplin, Mo.

REPLYING to L.M.'s question, my experience with roller bearings has proved that they are unequaled for use in dirty locations. On five 1,000-r.p.m. motors, the largest having a rating of 33 hp., on a slag pit crane, sleeve bearings had to be changed every six or eight weeks. due to the fine particles of slag working into the roll and cutting out the babbitt in the bearings.

Roller bearings were installed on these motors 3½ yr. ago, and since then there has not been a case of bearing trouble, although this crane is used 365 days a year. A direct saving is made on lubrication as these bearings need only a very little grease every few months.

The absence of grease or oil greatly lengthens the life of windings. All these motors are gear-driven and are subjected to very rough handling, as they frequently operate on heavy overloads.

If L.M.'s induction motors are of recent design it is quite possible that the sleeve-bearing end bells can be exchanged for new ones equipped with anti-friction bearings. Some machine work on the old shafts will be required. This work can usually be taken care of in any machine shop without removing the shaft. There are times, however, when it may be desirable to purchase a new motor shaft.

Several manufacturers of anti-friction bearings are prepared to supply bearing housings with their bearings, which can be placed in the old end bells after the sleeve-bearing housing has

been machined out. Such changes are frequently made on standard motors.

As some motor designs are more adaptable to anti-friction bearings than others, it is difficult to estimate the cost of a change over. In cases where the old end bells can be machined out to receive the anti-friction bearing with its housing, and the shaft can be turned to suit the bearing bore, a 15-hp. motor can be changed from sleeve to roller bearings for about $66.

Chief Electrician, O. C. CALLOW.
Trumbull Cliffs Furnace Co.,
Warren, Ohio.

Method of Removing Wires from Semi-Closed-Slot Motors

I shall appreciate it very much if some of the readers will tell me the best way to strip the stators of small series motors having semi-closed slots. I have seen a great many repair shops burn the insulation so that the wires come out easily. Does this in any way damage the iron or the insulation between the laminations? Can you advise me of a better method? Also, I should like to know the number of dippings and bakings that are necessary to make a first-class job on a motor.
Rome, Ga. M. S. C.

THE simplest method for M. S. C. to use is to burn the insulation off. This can be done by sending a strong current through the stator with the motor dismantled. If the insulation catches fire, let it burn long enough to char it.

As regards the effect of the heat on the iron, if it is not chilled too quickly or not allowed to become red hot and cooled quickly, so that the iron becomes hard and brittle, the core iron will be left in satisfactory condition. The writer has rewound quite a large number of stators and armatures that have been through fires, and they have worked satisfactorily.

Regarding dips and bakes, one long-soak dip and a long bake will be found satisfactory for general use, but more dips and bakes can be given to meet various conditions, such as would be necessary to make the machine oilproof, or moisture-, acid- and alkali-proof. For these more severe working conditions, from three to five dips will be necessary, depending on the varnish used and the severeness of the motor service. A. C. ROE.

Renewal Parts Engineering Dept.,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

IN REPLY to the question asked by M. S. C., it may be of interest to know that we strip the old windings from semi-inclosed slot motors by removing the rotor and applying 200 per cent of load current to the winding to be removed, but we do not permit the defective motor winding to become dangerously hot.

The minimum temperature that will satisfactorily loosen the varnish and cell insulation so that the old coils can be removed can best be found by practice.

We do not have any trouble from excessive temperature damaging the laminations, particularly if the original winding was dipped and baked, as the coils can be removed from the slots after the varnish softens. The coil ends can be cut off with a bolt cutter, or other similar tool, and pulled out endways or through the top opening in the slots. We find that this method leaves the slot insulation in good condition to be removed.

We bake all our rewound equipment as follows: The new winding is heated to about 70 deg. C. in a baking oven and immersed in a vat of good baking varnish, preferably one having a chinawood oil base. After immersing for about 10 min., it is removed and all excess varnish permitted to drain off. It is then put in the oven to bake for 12 to 18 hr. at 110 deg. C. The part should be watched from time to time during the baking period to see that pockets of varnish do not accumulate at any point on the winding.

It is very necessary that the specific gravity of the varnish be maintained at the proper value, and it is best to use a thinner recommended by the manufacturer of the varnish.

Chief Electrician, J. S. MURRAY.
Follansbee Brothers Co.,
Toronto, Ohio.

REFERRING to M.S.C.'s question, I would first heat the motor in an oven or in some other appropriate way, until all the insulation becomes soft. Then the wires of every coil should be cut off at both ends, with a wire cutter, chisel, or saw. After drawing out the retaining wedge, one may easily pull out that part of the coil that remains in the slots without damaging the core. Before trying to drive out the wedges, tap them sharply, as this will loosen them. Before dipping, the motor should be baked for 8 hr. in an oven at a temperature of about 200 deg. F.

After this operation, allow it to remain in the baking varnish for about 15 minutes or until bubbles cease to rise to the surface of the varnish. After a motor has been dipped in baking varnish and removed, it is essential that the excess varnish be allowed to drain off before baking. If this is not done, and the motor is baked in a horizontal position, the excess varnish will run to the low side and harden, thus causing the armature to run out of balance.

When a rotor or stator is put in a fire to burn off all the insulation, the varnish that is between the laminations in most motors is often destroyed, thereby causing eddy currents to circulate through the iron, when the motor is operating, and reducing its efficiency.

The baking process should be carried on for about 48 hr. at 200 deg. F. One dipping and baking is sufficient in most cases, but when service conditions are unusually severe two dippings and bakings are necessary.

H. J. ACHEE.

Superintendent,
City Water & Light Dept.,
Elk City, Okla.

ANSWERING the question by M. S. C., we prefer to remove wires from semi-closed slot stators in the following manner:

With the exception of one coil which is kept as a sample coil, we chop the coils off close to the laminations by means of a cold chisel and hammer on the side that they are connected. We do this first in order to free all connections.

Next, set the stator down with the cut ends of the coils next to the floor, and with a small pinch bar pry out each coil separately. By holding the hand over the nose of the coil you can pull out the top and bottom of the coil at the same time. Sometimes, if the coils are in very tight, it may be convenient to bolt the stator to the floor so that both hands will be free to work. On big stators we generally find it necessary to pull out the coils with a fast-operating chain block.

On armatures and stators that are made up of fine wire, we find it best to dip the coils in a lye tank to loosen the insulation. Boil for about 4 hr. in this solution, and then take part out of the lye tank and allow water to run over it in order to wash out the lye remaining on it.

After clipping the ends of the coils with a pair of end nippers, or tin shears, you can now easily pull the coils out from the other end of the slots by hand, and the insulation will also be loose in the slots. On armatures that are thus treated, it is best to remove the commutator before immersing in the lye solution or, if the commutator is difficult to remove, hang the armature in the tank in such a way that the commutator will not be in the lye. In order to keep the vapors away from the commutator, wrap a few turns of friction tape around the bars.

We consider burning out the coils or heating them with a blowtorch to be bad practice, as it is necessary to get the core nearly red hot before the wires in the slot loosen up, and this heat injures the coating of japan on the laminations. After the coils are removed, considerable difficulty is experienced in removing the insulation, for it sticks to the slots.

In regard to the baking of armatures and stators, it is good practice to preheat them before they are dipped in varnish in order to dry out the moisture, as the varnish seems to saturate the insulation better when the coils are hot than when they are cold. I find it better to bake armatures and stators longer and at a lower temperature than many winders do, for by so doing the volatile solvents in the varnish are given a chance to escape before the outside of the varnish is baked very hard. Generally, one dipping it sufficient for ordinary service, if a good coat of air-drying paint is used after baking. When the machine is to be used in chemical plants or outside work, we always dip and bake twice and then apply two coats of air-drying paint.

NICHOLAS J. WEISS.
West New York, N. J.

Electrical Service

AROUND THE WORKS

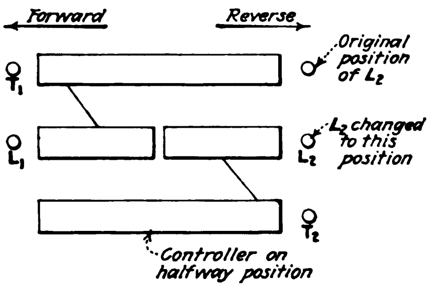
For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Trouble With Controller Due to Improper Assembly

A THREE-PHASE, 440-volt, hoist motor and drum controller, which had been recently installed, would not operate properly even though an experienced electrician on the job had checked all connections.

The drum controller was for both forward and reversing duty. The motor ran normally in the reverse direction, but the fuses were blown when the control handle was pushed ahead for forward operation.

After all the connections were checked



This diagram indicates change made in the location of the drum-controller contact fingers.

un. I sat down and watched the contact fingers make and break contact as the controller handle was moved through the forward and reverse positions. When the handle was moved into the reverse position it appeared to me that the segments on the controller were correctly located, but one of the contact fingers was not, thus causing a short circuit. So, as indicated in the accompanying diagram, contact finger L_2 was moved down one space in order to make contact with the middle segment. The motor then ran properly in both forward and reverse directions.

GRADY H. EMERSON.
Birmingham, Ala.

Changing Overload Protection to Meet Service Demands

AT ONE of our mines we have a 400-kw. and a 200-kw., 2,300-volt, steam-driven generator. As our day load requires the use of both of these units, the circuit breakers have to be set for the combined output of the generators. Our night load calls only for the 200-kw. unit and naturally our feeder circuit-breaker setting would be too high to give any protection to the small generator. If a trolley wire became grounded, or a heavy overload came in on the line, it would almost stop the generator, perhaps causing a fire by burning out bonds or causing damage to motors from low voltage.

In order to eliminate this danger we devised a way of installing an extra relay on each feeder, using the same current transformers, by setting one relay at 80 amp. and the other at 260 amp. These relays are thrown in or out of the circuit by a reconstructed G. E. contactor and are energized from the exciter current of the 500-kw. set.

When the turbine bus switch is closed the circuit for the contactor is automatically closed, which, in turn, connects the 260-amp. relay and the plant is ready for the day's work. When the turbine switch is opened, the contactor falls out and connects the 80-amp. relay for the 200-kw. set.

H. BANHOLZER.
Electrical and Mechanical Engineer,
Knox Consolidated Coal Co.,
Bicknell, Ind.

Incorrectly Assembled Dashpot in Compensator Cause of Operating Trouble

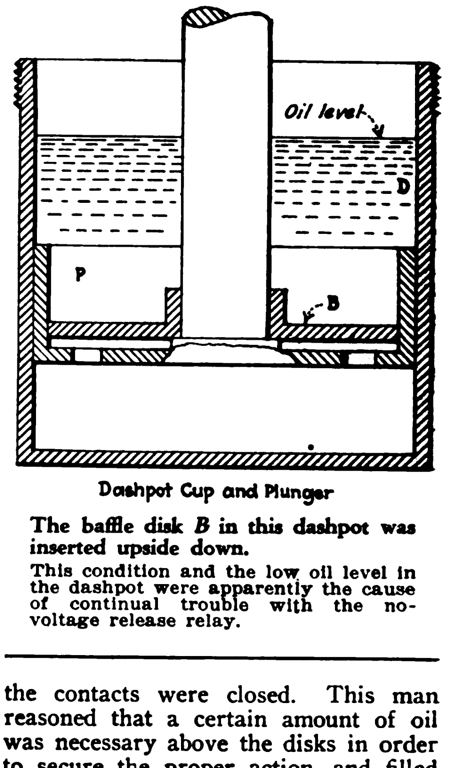
WHEN trouble occurs with industrial equipment there is always a reason, and a continual recurrence of the same trouble indicates that the cause of the difficulty has not been located. The need of a thorough, instead of a superficial investigation under such circumstances is well shown by the following experience.

On machine shop planers the greatest load occurs at the points of reversal of the table under average working conditions, although this is not true when cuts up to the extreme capacity of the planer are taken. It is at these peak points that belts squeak in time-honored fashion and here also that fuses are blown by the heavy current drawn, should an individual motor be underfused.

The largest planer in a shop manufacturing railroad equipment is driven by a three-phase, induction motor controlled by a compensator. After this drive had been in for some time, the no-voltage release gave trouble and an electrician adjusted the nuts on the dashpot rods to the limit for the fuses used. Soon the release showed that it was "tender" again and after several superficial examinations failed to locate the trouble, the planer hand adopted the scheme of blocking the starter lever over with a stick.

The planer was operated with this makeshift until it was noticed by a new foreman. This time another electrician was detailed to the job.

Unscrewing the dashpot, he noticed that it was less than half full of oil. It had been in that condition when the other men looked at it, but they had assumed that it was full enough, because the plunger was always immersed when



Dashpot Cup and Plunger

The baffle disk B in this dashpot was inserted upside down.

This condition and the low oil level in the dashpot were apparently the cause of continual trouble with the no-voltage release relay.

the contacts were closed. This man reasoned that a certain amount of oil was necessary above the disks in order to secure the proper action, and filled the cup to the level shown in the diagram with motor oil, as no other oil was available.

In the diagram D represents the dashpot cup and P the plunger. Filling the cut with oil helped, but did not overcome the trouble entirely. He changed the adjustment on the rod to the point where the switch would not stay in, and then adjusted the nuts until a good working position was reached without approaching the fuse capacity. Because of the difficulty of finding this position he investigated further.

He then found that the baffle disk B inside the plunger was turned upside down. Evidently someone who had

taken the apparatus apart had turned it over. This disk has a hub projection on one side and no hub on the other to govern the free passage of the oil. Putting the disk in as shown in the diagram gave an adjustment that appears to be perfect in that at the instant of reversal on the planer, the contacts ease off just enough to take up the mechanical play in the parts and then settle back.

This controller has worked satisfactorily ever since, which goes to show that a piece of equipment will do what it has been designed for, if given a chance.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Wrong Connections Cause of Motor Heating

A RATHER peculiar case of motor trouble occurred recently in a local plant. This motor had been taken down six months previously and placed in storage, and was to be mounted again in the original location. It was a three-phase, six-wire, 550-volt, 10-hp. machine, and was equipped with a star-delta starter. Both motor and starter were manufactured by the Crocker-Wheeler Co.

When power was applied and the starter handle thrown to the starting position, the motor hummed, but refused to operate. The line fuses were good; so the starter was examined, and the star point, which in this type consists of three segments short circuited by a brass rod, was found to have one segment open. When the rod was put into place again, and power applied, the motor instantly started and came up to speed. However, on throwing the starter handle to the running position, the motor gradually came to rest and began to heat up. The slackening of speed was a warning; so the switch was pulled and a large flash indicated an excessive current.

The rotor was examined for loose rotor bars, but they were in good condition. The motor was assembled again and started normally, but when the starter handle was thrown to the running side the motor immediately began to heat again.

As a last resort, the phases of the motor were rung out and each phase was tagged on both ends, regardless of the connections indicated on the motor diagram. Having located both ends of the three phases, one end of each phase was connected to the start side of the starter as previously tagged. This was accomplished by dropping the starter case, holding the handle in the starting position and tracing through the connections. The other three ends were connected to the remaining three wires from the running side. When power was applied, the motor came up to speed and when the handle was thrown to the running position, the motor settled down into its normal stride. It has operated without the slightest trouble ever since these changes were made.

Later, it was discovered that the man who took the motor down cleaned it and painted the leads previous to placing it in storage. In order to paint the leads, he took the terminal block apart and in replacing it mixed up the six leads. He was afraid to mention the mistake and, consequently, trouble developed when the motor was connected according to the diagram.

H. G. MILLICAN.
Kingston, Ont., Can.

Portable Gage for Determining Depth of Water in Wells

IN ORDER to operate efficiently the condensers in our plant, it is necessary to know the water level in the various wells that supply water to the condensers. So far, we have employed successfully only one method of determining the water level in these wells.

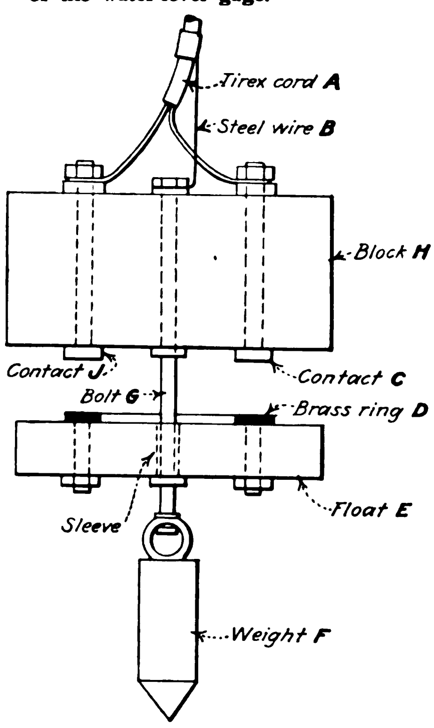
This method involves the use of a float equipped with suitable contacts, which is lowered into a wellcasing until an alarm bell rings. The ringing of the bell indicates that the device has been lowered to the water level.

Referring to the diagram the body of the device that is lowered into the casing is made in two parts, *H*, and *E*. The float, *E*, is guided by a bolt, *G*, so that when the device is lowered to the water level, the water raises the float until the brass ring, *D*, short-circuits the contacts *C* and *J*. When these contacts are short-circuited, current flows through the Tirex cord, *A*, to the signal circuit. In order to keep the device in an upright position a weight, *F*, is hung on the lower end of the bolt, *G*.

As the steel suspension wire, *B*, is graduated in feet and inches, the depth of the water level from the top of the casing can be read directly when the bell rings.

CHAS. A. PETERSON.
Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

This diagram shows the construction of the water-level gage.



Equipment Record System

(Continued from page 419)

bearings in our motors were plain-bronze, grease-lubricated and in our service lasted generally from 3 to 6 months. They were a source of continual annoyance and expense. The expense was not limited to replacement of bearings but often extended to electrical trouble, with the consequent rewinding of armatures and field coils, and, in addition, the interruptions to operation.

About 5 years ago one of the 25-hp. crane motors was arranged for ball bearings, as an experiment, with housings of our own design. After it had been in service 21 months, it was taken down for examination and found to be in excellent condition. It was returned to the crane so we proceeded to install ball bearings on other motors. To date, about 30 crane motors have been changed over to ball bearings. Some of these have been in service 3 years and are still in service. We have had no trouble worth mentioning. These cranes are in service practically 24 hr. a day and make hundreds of lifts.

These motors, which formerly were a source of continual worry and expense, are now the least of our worries. A comparison of life of a few months for sleeve bearings with a number of years for ball bearings has convinced us as to which is better, at least for our service. We made the mistake of installing ball bearings which were over-rated for the job, but they are giving us excellent service. The photograph at the beginning of the article shows one of these motors with the upper half of the frame removed.

No claim is made that our system is 100 per cent perfect or that it is the last word. In fact, it has many flaws, as we are finding, but we are correcting and improving it continuously; however, it is working with some measure of success and is presented here, with the hope that some who read this may get some hint or idea that may be of use to them. If this should be true my writing and your reading shall not have been in vain.

MECHANICAL MAINTENANCE OF *Power Drives*

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Babbitting in Bearing Seats for Ball or Roller Bearings

USE of ball or roller bearings, when rebuilding old equipment or when constructing new or special machinery, is often passed up on account of the cost, which is made up of two items: namely, the cost of the bearing itself and the cost of making the bored and capped seat for the bearing. This higher first cost often causes the anti-friction bearing to be thrown out on a design in favor of its less expensive, plain competitor, without regard to future service or to ease of renewals.

The benefits of anti-friction bearings at lowered cost may be secured by setting these bearings in babbitt seats. This makes an inexpensive mounting that is exceedingly durable on a wide range of machines, although not usable in all cases. The writer has mounted a number of Timken and New Departure bearings of No. 305 size and larger in this manner and feels sure that the construction is satisfactory because the machines have been out in use for some time and no complaints have ever been registered.

Recently, some special material-handling machinery was built in which the practice of babbitting in was followed. For example a gear box for one of these machines contains four bearings in a length of 12 in., as shown in *A*. Three of these bearings were inexpensive, commercial ball bearings, whereas the fourth was a Gurney ball bearing which takes both thrust and radial loads. Thus the easy running and cheap renewal qualities of ball bearings were secured at a minimum of cost.

Cored holes in the cast-iron case, *A*, allow the shaft to pass through with ample clearance. The bearings were set in larger recesses at the ends of these cored holes. The method of installation used was to have a plain shaft for babbitting purposes. On this shaft were placed dummies of the same size as the bearings. These dummies consisted of cast-iron collars *B* with setscrews in the hubs, which were placed at measured intervals along the shaft after the latter had been set inside the casing. Babbittrite was used for the dam and the shaft was positioned by measuring from machined surfaces on the case.

The case was heated and the babbitt was poured at a low temperature. Anchor holes for the babbitt were placed in openings in the cast-iron case to insure a tight fit of the babbitt in the casing.

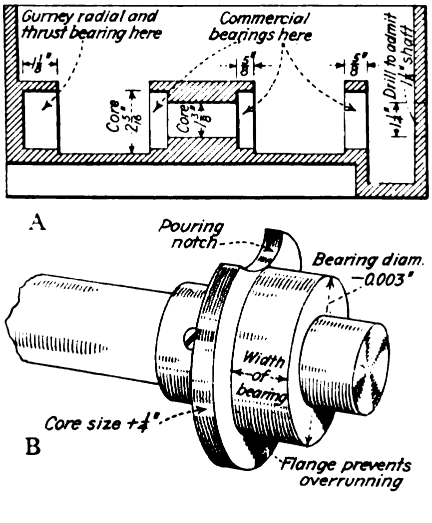
Upon removal of the dummies, the bearings were inserted. The collars were 0.003 in. smaller than the bearings, so that the bearings had to be squeezed into position. This holds the bearings tight and presses the babbitt back into the casting. A further advantage of the babbitt seat is that it makes possible the use of anti-friction bearings by shops that do not have boring facilities, because shafts can be placed without machine work. Also, it makes possible a last-minute change or a shift in position to make gear centers come better or parts engage as they need to be, as found necessary while assembling.

The drawing *A* shows the half gear case mentioned. The same size of core was used throughout, which lessens the pattern cost and leaves ample room for both makes of bearings. For manufacturing reasons, the end hole (where the shaft is put through) is drilled and can be plugged, if it is desired to run the gears in oil. The collar or dummy *B* may be left plain or made with a flange. The flange prevents overrunning and end-trimming after pouring and where more than one job is to be done, it will pay for itself. DONALD A. HAMPSON.

Plant Superintendent
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Fixture for casting babbitt seats for ball or roller bearings.

Three commercial ball bearings and a Gurney radial and thrust bearing were to be placed in the gear box *A* of a special machine. The holes for the shaft and bearing were cored out and a mandrel fitted with flanged babbitting dummies *B* to cast seats for the bearings. This method of seating ball or roller bearings may be used on certain types of work at a saving in installation expense.



Recommendations for Applying Belt Dressings

WHEN a belt is bent around a pulley the internal fibers rub on each other. Unless the fibers are properly lubricated their resistance to wear is lessened, resulting in a shorter life, according to some information on belt operation, which was recently issued by Chas. A. Schieren Co. A suitable dressing provides the necessary lubrication to reduce this wear.

All belting should be dressed periodically. In very dry places it is good practice to dress a belt lightly every two or three weeks; in other places belts may need attention less often, depending on the service and amount of dressing applied. Many belt men apply a preservative dressing to the outer ply and allow the greases to penetrate through the leather. If the inside surface is very dry, a small amount is applied to this surface until it softens. By applying most of the dressing to the outside the surface never becomes slippery. It is not necessary to wait for a shutdown or week-end; but dressing can be applied while the belt is in operation, or at the noon period.

Applying the dressing to the outside of the belt is very good practice for belts operating in dusty places, such as flour mills, and so on. The application of a dressing to the outside, after brushing the dirt off, keeps the pulley surface from becoming gummed up. This keeps the belts in the pliable condition necessary for economical service.

Often the face of a cast-iron or split-steel pulley will become very shiny. This condition means that the belt is slipping and polishing the surface. Sometimes this condition requires the use of a larger belt. Leather belts that polish the face of the pulley do so because they have been allowed to dry out and become harsh and hard on the surface.

The application of a good belt dressing that will soften up the harsh leather surface will remedy this trouble. The shiny surface will disappear and a dull, smooth one take its place. It is this latter type of surface that is capable of transmitting heavy loads.

Use of Silent Chain Drive on Surface Grinder

THE management of a factory some time ago bought a surface grinding machine equipped with a magnetic chuck for their particular work, but no thought had been given to the details of how it was to be driven. The magnetic chuck required direct current for its operation, whereas only 60-cycle a.c. service was available.

In addition to this handicap the work in hand had to be ground dry but the machine was arranged for wet grinding, which is usually the case. The problem was eventually solved in an unusual manner, homely, but at minimum cost.

After the machine was received it was decided to change the location originally intended for it, which placed it out of reach of available line shafting. The first step was to remove the pump and its piping, leaving the upper part of the tank for a working surface upon which four flat bars of steel were laid and bolted down. The tank was cast integral with the base, having a ⅜-in. wall that had been machined for a cover. A 5-hp. induction motor was installed with a slide base on two steel bars of the tank cover, allowing but 3½ ft. for pulley centers.

It was now readily foreseen that a pulley drive would be troublesome, so a Morse silent chain drive was ordered and installed as shown in Fig. 1 of the illustration. This chain drive, comprising a 23-tooth driving sprocket turning at 1,140 r.p.m. and a 48-tooth driven sprocket, has operated 9 hr. a day for five years, without the slightest expense or trouble.

The grinder was driven by the a.c. motor, but the Walker chuck requires direct current. A small generator and the necessary control is expensive; neither can such equipment be picked up at random in small towns, but someone suggested using a small dynamo that had been employed in experimental work. We found it to be an old Peerless dynamo rated at 1 hp. and 110 volts.

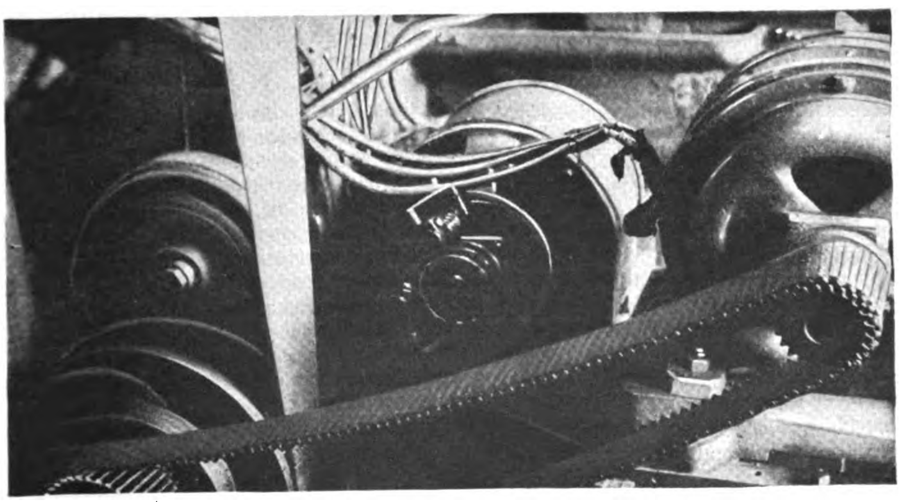


Fig. 1—The grinder is driven by a 5-hp. induction motor through a silent chain.

There are 28 teeth in the driving sprocket, which turns at 1,140 r.p.m., and 48 teeth in the driven sprocket. The distance between shaft centers is 3½ ft. A Morse silent chain is used on this drive, which has operated 9 hr. a day for five years without trouble or expense.

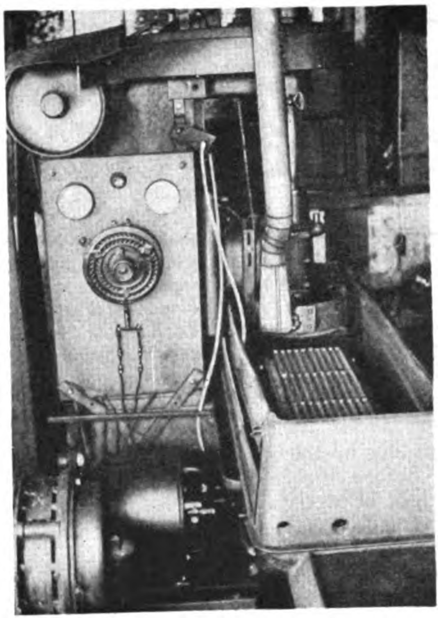


Fig. 2—This shows how the driving motor and direct-current generator were mounted on the tank which was part of the grinder.

This equipment was very satisfactory, as the chuck required only 5 amp. at 110 volts. A slate switchboard was found and mounted on the grinder column, out of the way but with the voltmeter within the operator's line of sight, as shown in Fig. 2.

The generator was mounted on its pair of bars on the tank cover between the motor and the grinder column, directly in front of the switchboard panel.

Now by rearranging the feed belt drive a pulley was available for a take-off through which a 1½-in. belt could be run to the generator. As there was no sliding base with the generator, belt tightening was impossible. However, after it had been thoroughly proven that some means of taking up belt stretch must be provided, a tightener of the Lenix type was culled from the shelves and bolted to the dynamo. In order to keep down the surface speed of the idler pulley another pulley consisting of an old bronze bushing on which was pressed an impregnated wood bushing made by a New England firm was put on the stud.

This arrangement provided a quiet, slow-speed drive and to say the least, it is an interesting combination in which there is an a.c. motor and chain drive for the grinder, a d.c. generator with belt drive and tightener, and a wood-bushing idler pulley.

DONALD A. HAMPSON.
Plant Superintendent
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Lubrication Insured by Control Devices and Warning Signal

AN interesting combination of control devices and warning signal has been installed by the Power River Co., Vancouver, Can., to prevent failure of the lubricating system on a large generator, and to prevent overheating of the generator thrust bearing. Upon failure of the main oil pump, a reserve pump is immediately started and a signal is sounded. The signal is also sounded when the thrust bearing overheats.

The oil pump, which is regularly used during the operation of the generator, is driven through gearing from the generator shaft. An independent motor-driven oil pump is also provided, with equipment for hand starting. Should the geared pump fail to operate, the motor-driven pump will go into service automatically.

This is accomplished by a General Electric pressure switch which is installed in the discharge side of the geared oil pump. With this arrangement, if the pressure of the geared pump drops, the pressure switch closes a magnetic switch, starting the motor-driven pump and sounding an alarm which operates on a 125-volt a.c. circuit.

The second pump, however, operates until normal conditions are restored and pressure is again being delivered by the geared pump, whereupon the contacts of the pressure switch open and the motor-driven pump is shut down.

The thrust bearing on the generator is equipped with a Tycos thermostat alarm control that operates a 125-volt, direct-current industrial signal when the temperature rises above a pre-determined maximum.

Owing to the fact that the contacts of the thermostat are designed for operation only in low voltage circuits it was necessary to employ a bell ringing transformer to supply the current for closing the small relay that connects the alarm signal to the 125-volt d.c. circuit. This simple system of control devices insures reliable and efficient lubrication at all times.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Simple Tests to Determine Condition of Medium-Sized D.C. Motors

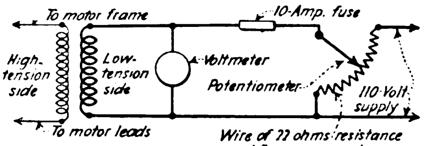
THE object of the simple tests that are to be described is to determine readily the condition of small and medium-sized d.c. motors, and to locate any weak spots that are likely to give trouble in the near future.

It is generally best to begin the examination of any motor by first inspecting the bearings. The condition of the bearings on the pulley end of the shaft may be determined by prying up under the shaft, or under the pulley if on the shaft, with a lever and in so doing the amount of play in the bearing may be noted. The condition of the bearing on the commutator end of a d.c. motor shaft can be determined by removing the end cap on the bearing housing, so that one can pry up under the shaft with a screw driver or a light bar, using the bearing housing as a fulcrum to pry on while observing play in the bearing. When the bearing lining projects out past the end of the shaft a 6-in. x 6-in. piece of wood may be used to pry on. Another method that might be employed to determine the amount of bearing clearance is to insert feelers or thickness gages between the shaft and the bearing lining. When a bearing is found with too much clearance, it should be inspected later on when the motor has been taken apart. The oil rings in the bearing should also be inspected to see if they turn freely and, if they do not, it will not take long for the bearing to burn out.

Next, it might be well to make a ground test on all of the windings. After connecting all the external leads together, a ground test can be applied simultaneously to the shunt and series fields together with the armature and brush rigging. A variable resistance connected as a potentiometer in the primary side of an ordinary single-phase transformer may be used to supply the test voltage, which should be increased gradually. If the coils appear to be in fairly good condition a test voltage of twice the normal motor voltage plus 1,000 volts may be applied for one minute.

The accompanying illustration shows how the voltmeter, small protective fuse, 110-volt supply line and the variable resistance should be connected to the primary side of the transformer. After the testing current has been applied, a zero reading on the voltmeter indicates a ground, and a ground is also indicated by the voltmeter reading falling to zero after the test current has been applied. The voltage of the test current may be determined by multiplying the voltmeter reading by the ratio of the transformer.

Before the motor is taken apart it might be well to give it a running test. A small, variable-voltage generator may be used to advantage to supply the test current, but if such a generator is not available a variable resistance may be used in series with the armature circuit in order to vary the test current. A low voltage should be applied to the motor at the start, and as the motor increases its speed the voltage may be gradually increased up to the rated voltage of the motor. While this is being done, the motor should be watched for sparking at the brushes, vibration noise, heating of the windings or bearings, and the no-load current reading should be checked with the rated no-load current marked on the motor nameplate.



This shows the transformer connections for applying a high-voltage test to motors.

The test voltage is determined by multiplying the reading on the voltmeter by the ratio of the transformer used.

If the various tests that have been applied so far indicate that the motor is in good condition, the motor may be taken apart. While applying a little less than the rated voltage, or the rated voltage, to the field coils when they are connected in series, a voltmeter reading should be taken across each field coil. The voltage drop across each coil should be the same and the sum of these voltages should equal the applied voltage. This procedure will determine whether or not the field coils are free from short-circuits or whether any of the coils are open. After the test current has been applied to the field coils, it might be well to check the coils with a compass for polarity. While moving the compass around the frame the successive poles should alternately indicate N and S.

While examining the condition of the armature, it is well to make a test for short-circuits in either the coils or between the commutator segments. One common way of checking the coils in the armature for short-circuits is by means of a growler. This is a laminated, two-pole magnet which is wound with a certain number of turns of wire, and is suitable for operation on an a.c. circuit. After placing the armature on the growler, a hacksaw blade or a thin piece of iron may be placed over the uppermost armature slots. A short-circuit will be indicated by the saw blade vibrating violently. If an ammeter is connected in series with the growler, an increase in current is indicated when the short-circuited coil is under the influence of the growler flux.

A millivoltmeter may also be used to check the condition of the armature by applying its terminals to two adjacent commutator segments. The commutator segments on either side of these two segments are energized from a dry battery, thereby causing a normal reading of the millivoltmeter when the coils are in good condition, a high reading when there is an open-circuit, and a low reading when there is a short-circuit. If a telephone receiver is substituted for the millivoltmeter, a normal buzz will indicate that the coils are OK., a loud buzz will indicate an open-circuit, and no buzz will indicate a short circuit.

Very often the brush-holder on a d.c. motor has been moved out of the neutral position, and when this mark cannot be found it is difficult to determine the neutral position of the brushes. To check the neutral position of the brushes on the commutator apply about one-half normal voltage to the shunt field, and while the terminals of a low-reading voltmeter or a millivoltmeter are making contact with two adjacent commutator segments, open the field control circuit and note the amount of deflection on the scale of the meter. There should be very little or no deflection when the meter terminals are making contact with the commutator at a neutral brush position.

A general inspection should also be made to note the condition of the brushes, brush shunts, condition of varnish and insulation of the field coils, and the bolts holding the field coils to the frame, to see that they are tightened up. The condition of the armature bands should not be overlooked, and the connections between the coil leads and the commutator bars should also be inspected. A continuous overload often causes the solder that holds the coil leads to the commutator bars to melt, and due to the centrifugal force of the armature revolving the melted solder is often thrown off, with the result that a silver-like line of solder sticks to the field frame or coils.

Los Angeles, Calif. E. LINDOP.

Quick Method of Stripping Closed Slot Armature

ORDINARY soda ash, which is comparatively cheap, can be used as a means of quickly stripping a closed-slot armature. Before soaking the winding in the boiling solution of soda ash (also lye and Oakite can be used for this purpose), the commutator should be removed or pains be taken to cover it and keep it out of the solution, if the commutator is in good condition. But when it is necessary to remica the commutator, the whole armature can be submerged in the solution in this case.

To hold the armature, put a lathe dog on the commutator end of the shaft and either dip the armature until the winding is submerged or hang the armature over the tank and pour the solution over the winding.

After an armature has been stripped by this method, it must be well dried by baking in order to drive out all moisture between the laminations. When the new winding is in place, the armature should be dipped and baked.

As dipping and baking is common practice today, this process will fill the space between the laminations with varnish. So it is obvious that any armature handled by this method will not heat up on account of the solution removing some insulation between the laminations because these spaces between the laminations will be filled again during the varnish dip. The ash solution in addition to removing the coils will also clean out the air ducts, thus improving the ventilation of the machine. A. C. ROE.

Renewal Parts Engineering Dept.
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

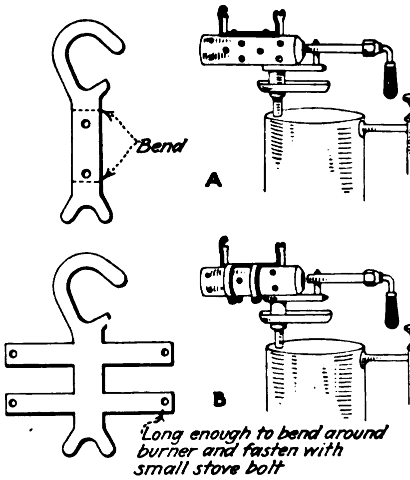
How to Care for a Blow Torch

FEW tools receive such hard service or so little care as a blow torch, yet it is not difficult to keep them in good condition. When in use, they are operated at a very high temperature that expands the metal of which the burner is made. For this reason do not close the needle valve tightly after the flame has been extinguished because upon cooling the contraction of the metal will in this case cause the needle hole to be gradually enlarged and cause trouble.

Asbestos cord with a small amount of graphite makes a satisfactory packing for the glands, which should be kept tight enough to prevent leakage. The pump leather should be oiled occasionally with a vegetable oil in preference to a mineral oil, as the latter will harden the leather. The check valve will seldom require any attention except possibly through renewal of the cork.

The practice of excessive pumping of air into the reservoir is quite common, but should not be done because operating the torch with a high pressure in the reservoir is dangerous.

Most torches, when new, are equipped with a device to hold a soldering iron in place over the flame. These hooks



This shows how an iron holder is fastened to a blow torch.

frequently break off, but when this happens they can be readily replaced, as indicated in the accompanying diagrams. To do this take a piece of heavy sheet iron and bend it as indicated at the dotted line in the diagram, and then fasten it to the burner by means of two machine screws as shown in *A*. The hook shown in *B* is the same, except that two straps have been added which are turned under the burner and fastened with small stove bolts as shown in the illustration. C. A. P.

Fairbanks, Alaska.

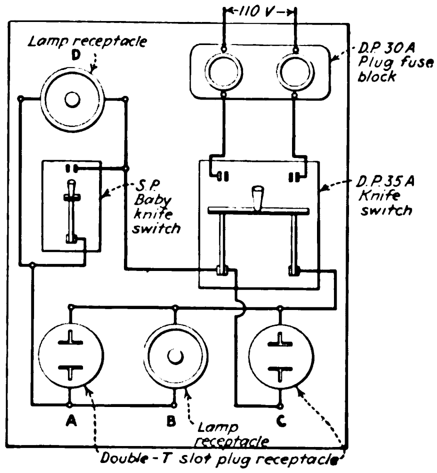
Simple and Inexpensive Type of Appliance Test Panel

IN OUR shop we have six 110-volt test panels in daily use which have covered our needs in the repair of appliances, etc., for many years past.

The panel is 8 in. x 10 in. over-all and is made of $\frac{1}{8}$-in. asbestos on a $\frac{7}{8}$-in. board backing. The fuse blocks, switches and receptacles are mounted on the asbestos as shown in the illustration.

The upper receptacle *D* is wired in series with *A* and *B*, across the terminals of the double-pole knife switch. The double T-slot plug receptacles at

This 110-volt test panel simplifies appliance repair work in the shop.



A and *C* can be placed across the line when both knife switches are closed. The receptacle at *B* is for the occasional appliance or cord with a non-separable plug.

Most of the time a lamp is kept in receptacle *D* to facilitate short-circuit or open-circuit tests on appliances plugged in at either *A* or *B* and the full line voltage is applied by closing the single-pole knife switch.

Receptacle *D* may be used to accommodate an ammeter when it is necessary to determine current consumption and by utilizing the potential from receptacle *C*, wattmeter tests may be given. GARSON A. REESE.

Manchester, N. H.

Emergency Repair of Defective Generator Field Coil

WHILE I was in charge of the electrical equipment in a plant where 200 men were employed in fabricating steel and producing castings, the failure of a 75-kw., 230-volt, d.c. generator supplying only 25 per cent of the plant load caused the entire plant to shut down one day at 5 p.m. Three-phase, 440-volt power was used on 75 per cent of the machinery, but due to an old installation of d.c. cranes, upon which the entire plant depended, it was necessary to generate d.c. power for their operation.

A hasty examination showed the main fuses to be intact, and after a short time the trouble was found in one of the field coils.

The generator field coils were pyramid-shaped in order to use a large number of turns of wire and still have the coils fit in the available space. The defective coil was removed after a test showed it to be open.

The field coil and polepiece were chucked in a lathe to enable us to remove the winding. A measurement showed that the wire was square, but square wire of this size was not kept on hand. A telephone call to a large electrical house in a city 30 miles away found no one on hand except a night watchman. The electrician, in the meantime, was instructed to remove the wire from the coil by hand; so a helper slowly revolved the lathe head by pulling on the drive belt.

At 11 p.m. the supply-house promised to forward the necessary wire by messenger. The "open" in the field coil was found about this time. It was 210 turns from the starting end. At 1:15 a.m. the messenger arrived with the wire, which was carefully attached to the undamaged section by means of a copper sleeve and hard solder. The coil was then rewound in accordance with our notes and at 4 a.m. it was replaced in the generator.

A short run showed that all was in perfect order and ready for operation when the men came in at 7 o'clock.

CHAS. A. PETERSON.

Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

New Equipment

for plant operation and maintenance

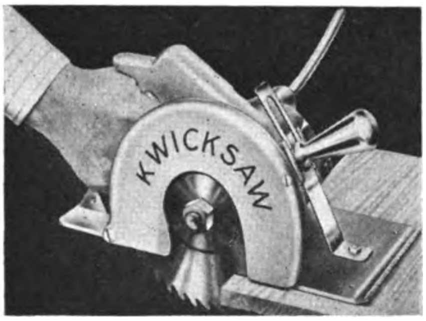
Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Electrically Driven Handsaw

THE addition of the Kwicksaw, an electrically-driven handsaw, to its line of woodworking machinery has been announced by The Porter-Cable Machine Co., North Salina and Exchange Sts., Syracuse, N. Y. The Kwicksaw weighs 10 lb. and can be operated with one hand.

The saw is mounted directly on the special motor armature, that runs on ball bearings packed with grease. The wide supporting shoe carries the weight of the tool, prevents tipping, and aids in securing square cuts, it is claimed. By loosening the front handle, the hinged supporting shoe can be set for any depth of cut up to 2 in.

Standard equipment consists of 10 ft. of rubber-covered conductor cable with an armored duplex plug and one 7-in.



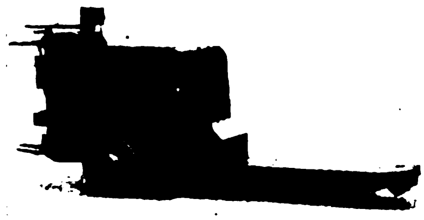
Kwicksaw Manufactured by Porter-Cable Machine Co.

combination saw which may be used for both ripping and cross cutting. A universal motor wound for 110 or 220 volts, as specified, which will operate on direct current or alternating current of 25 to 60 cycles, is used.

Elevating Truck

ANNOUNCEMENT has been made by the Baker-Raulang Co., Cleveland, Ohio, of its new Series E elevating trucks. During the elevating operation the platform is pulled up four inclines by two roller chains. The platform travels a maximum of 9 in. with a net lift of 6 in.

An inclosed magnetic disk brake mounted on an extension of the armature shaft brings the motor to rest after the limit switch operates. The control switch for the elevating motor is mounted on the dash where it is accessible. By manually operating this switch the hoist may be stopped at any point and started up again or reversed as de-



Baker-Raulang 3-ton, Series E Elevating Truck

sired. It is not necessary to go through the entire cycle of operations to complete the lifting or lowering movement.

The automatic switch is interlocked with the controller and brake pedal so that it is said to be impossible to operate the truck except by a conscious and sustained movement on the part of the operator.

The frame is fabricated from structural steel and the other parts of this truck are Baker inter-standardized units. The trailing axle consists of an alloy steel forging and each wheel turns on an individual knuckle and is fitted with two Hess-Bright, radial ball bearings.

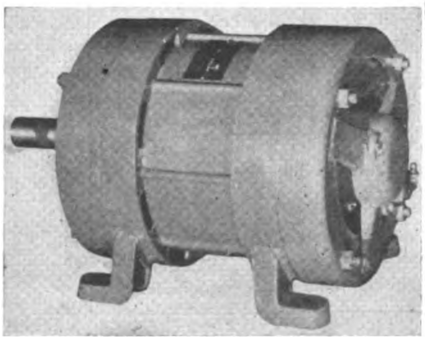
These trucks are built in different sizes to accommodate weights of 3 tons, 5 tons, and 10 tons, respectively.

Steel Induction Motor

A COMPLETE line of all-steel, ball-bearing, polyphase induction motors, ranging in size from 1 to 100 hp. in all standard voltages and cycles, is announced by the Lincoln Electric Co., Cleveland, Ohio. Hot-rolled steel has in these motors entirely replaced the grey iron and malleable castings which were formerly used.

It is claimed that every part of the motor is at least twice as strong as the former type which was built with a cast-

Lincoln Electric Co. All-Steel, Ball Bearing Induction Motor



iron frame. Drop-forged steel feet are welded onto the hot-rolled steel end rings of the motor. The end brackets or bearing supports are also made up of welded steel construction.

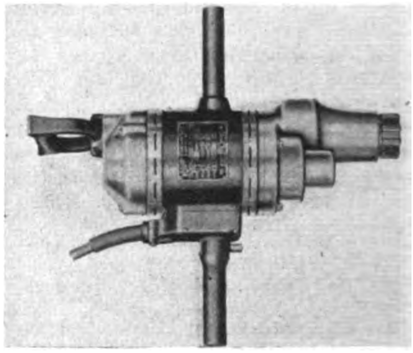
Less thickness of material is required in the frames of the new motors and, it is claimed, the increased ventilation so obtained results in a considerable increase in the overload capacity of the motor; so that a continuous overload of from 10 to 50 per cent can be handled by the motors, depending upon the size and speed.

Universal Drill

ADDITION of a standard-duty, $\frac{7}{8}$-in. capacity universal drill to its line of electrical tools has been announced by The Hisey-Wolf Machine Co., Cincinnati, Ohio.

The motor has ball bearings which are said to be fitted in such a way as to eliminate slip and creeping action. The gear on the armature shaft is removable.

The drill spindle, which is of liberal dimensions, is hardened and ground, and is automatically lubricated through the gear case. It is fitted with a No. 2 Morse taper socket.



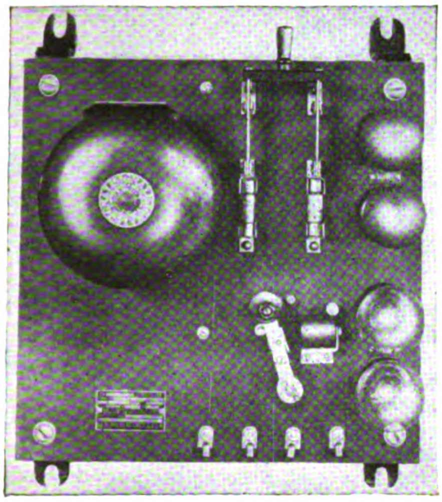
Hisey-Wolf $\frac{7}{8}$-in. Universal Electric Drill

In order to provide brush adjustment when necessary, the brush holders are mounted as a separate unit on a Bakelite yoke. The drill weighs 25 lb.

High-Low Water Alarm Signal Panel

A NEW signal panel has been designed for use with pump installations, especially in buildings, by the General Electric Co., Schenectady, N. Y. This warning signal, known as the CR-4779-A-1, is for the purpose of calling an attendant in case of danger from overflow or emptying of the tank.

The panel is governed by one or two float switches, and an audible signal sounds immediately when either the predetermined high or low level of water is reached. The gong can be silenced by the attendant upon his arrival, and the silencing switch does not have to be manually reset after the float switch takes a normal position. High and low signal lamps are provided, either of



G. E. High-Low Water Alarm Signal Panel

which lights when the predetermined level has been reached, remaining lit until the float takes a normal position.

The panel can be used for a one-level signal by omitting the float switch for the other level. It can also be used on pressure systems but, when single-pole float or pressure switches are used, it is necessary to add a relay in place of the other pole.

Hydraulic Jacks

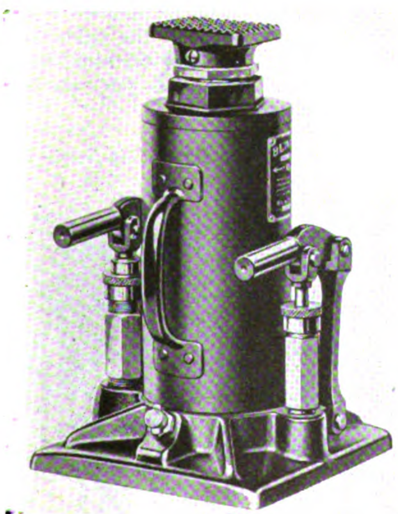
Announcement has been made by the Blackhawk Manufacturing Co., Milwaukee, Wis., of the marketing of a complete line of hydraulic oil-power jacks, ranging from a 1½-ton model to a 75-ton industrial unit. Although these jacks have been made and distributed under another name on the Pacific Coast for the past five years, they have been further improved and standardized by the Blackhawk Co.

The Twin-Chek valve unit, a patented feature, is located below the pump, and in an easily accessible position for removal for cleaning or replacement.

Lowering is done automatically with a controlled release valve; the speed is governed by the operator. The handle of the jack, in addition to being used for lifting purposes and for placing the jack at long range, is used to open the release valve for lowering, to control the drop, and to withdraw the jack.

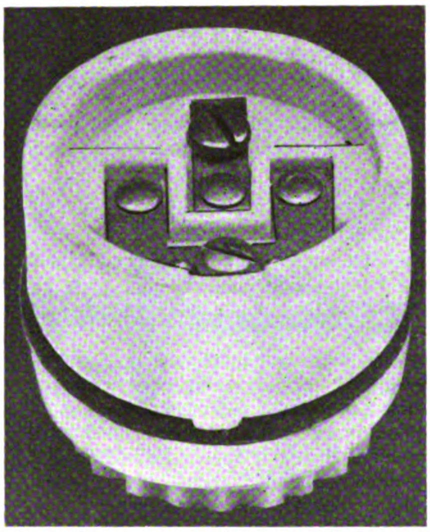
The complete line of Blackhawk hydraulic oil-power jacks consists of ten models in nine capacities. The 18-ton, model E-14 unit, illustrated, weighs 60 lb., is 14 in. high, and has a lift of 8¼ in., which gives a total height of 22¼ in. when extended.

Blackhawk 18-ton Hydraulic Oil-Power Jack



Porcelain Receptacle

Announcement has been made by the C. D. Wood Electric Co., Inc., 565 Broadway, New York, N. Y., that they have added to their line of electrical wiring devices a two-piece porcelain receptacle for ceiling fixtures, outlet boxes, and sign work.



Wood Two-Piece Porcelain Receptacle

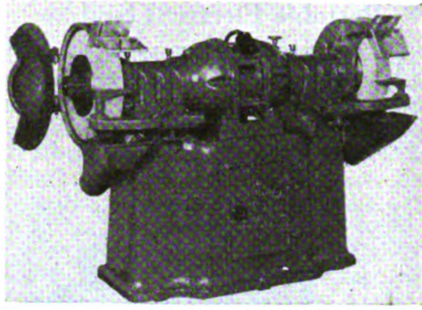
This receptacle, designated as No. 444, has the terminals recessed and entirely enclosed on the sides so that the receptacle may be sealed up and made weatherproof, after the wires are fastened to the terminals. The recess is made deep enough to cover the heads of the screws, which are polarized.

Electric Grinder

A heavy-duty, electrically driven grinder which is made in 5-, 7½- and 10-hp. capacity respectively, has been added to the line manufactured by the Standard Electrical Tool Co., Cincinnati, Ohio. The 5-hp. grinder carries two wheels, each 18 in. in diameter with 3-in. face and 2-in. bore, and weighs 1,920 lb. The 7½-hp. grinder carries wheels 24 in. in diameter with 4-in. face and 2½-in. bore, and weighs 2,020 lb. The 10-hp. grinder carries wheels 24 in. in diameter, with 4¾-in. face and 2¼-in. bore, and weighs 2,375 lb.

These grinders are equipped with General Electric push-button control and 40-deg. General Electric motors fitted with four SKF deep-grooved ball bearings incased in dustproof chambers. The armature shaft is provided with a locking device to be used when changing wheels.

The emery wheel guards are of the hinge-door type with exhaust connections. Each guard is fitted with a spark breaker as well as a polished, wired-glass eye shield.



Heavy-Duty, Electrically Driven Grinder, Made by Standard Electrical Tool Co.

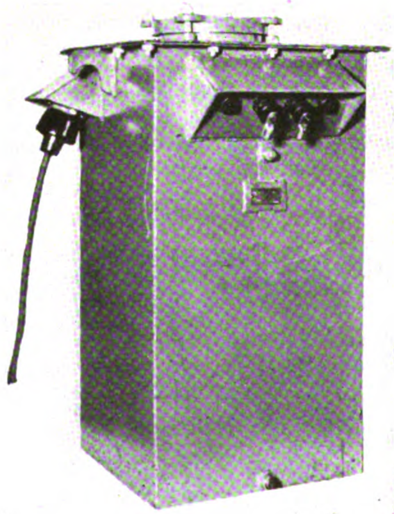
Distribution Transformers

New distribution transformers for industrial application, which are designed and constructed to operate under severe conditions of vibration and handling, have been introduced by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. These transformers, known as Types SB and SKB, have extra-heavy bracing to protect the coils and iron in the tank. The transformers may be made absolutely oil tight, it is stated.

Two important applications of these transformers are in the oil fields and in mines. It is claimed that these transformers may be transported on their sides without injury or danger of any oil leaking or splashing out.

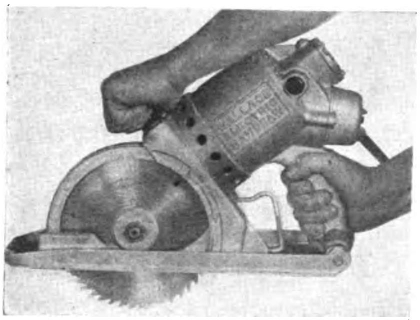
They can be safely used on electric shovels, trucks, railway cars and other equipment where unusual vibration is found.

Westinghouse 25-kva. Distribution Transformer



Portable Electric Handsaw

ANNOUNCEMENT is made of the addition of an electric handsaw to the line of portable woodworking machinery manufactured by J. D. Wallace & Co., 2808 Wilcox St., Chicago, Ill. A



Wallace Portable Electric Hand Saw

universal type of ball-bearing motor of standard make is used to drive the saw spindle, and the gears run in grease. An 8-in. standard round-hole saw blade is the largest size that can be used.

In operation the safety guard is released by means of a trigger conveniently placed near the grip. When the cut is finished and the saw is lifted from the work, the safety guard or shoe automatically drops and locks in position, covering the blade.

A splitter follows the saw blade, drops into the cut, and helps to guide the machine. An indicator in front makes it possible to follow a line, and the shoe is machined on one side to follow a guide rail.

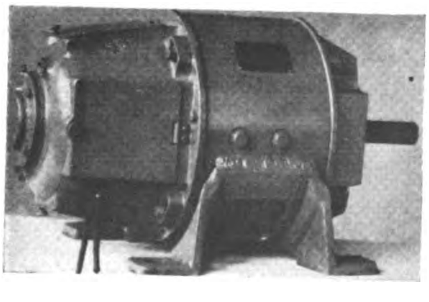
With the depth gage which is provided, the saw can be set to cut to any predetermined depth.

Hoist Motor

A NEW motor has been developed by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., particularly for use on portable type room hoists in mines. Across-the-line starting is permitted with negligible disturbance at the commutator on this type RH, totally enclosed motor, rated at 5 hp., 15 min., 55 deg. C. temperature rise, 1,150 r.p.m., compound wound, 115, 230 or 550 volts.

The armature coils are so constructed and installed that a single coil can be replaced with a minimum disturbance of the other coils. In addition to each

New Westinghouse Type RH Motor.



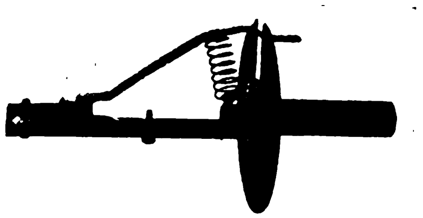
coil being specially insulated, the shunt and series coils for one pole are assembled as one unit and then dipped and baked in this form, special precautions are taken to insulate the coils from each other and from the ground.

The RH motor is rugged in construction, having a rolled steel frame and drop forged steel feet that are welded to the frame. The bearings are of the heavy duty roller type and the motor can be operated in an inclined position. The inclosing covers are hinged to the bracket and can be raised for inspection of the brushes and commutator by loosening one screw. There are a total of four covers, giving easy access to these parts.

Electrode Holder

A HOLDER for metal electrodes has just been introduced by the Lincoln Electric Co., Cleveland, Ohio. This 600-amp. holder, known as Type TR, handles an electrode as large as ¼ in.

Many improvements are claimed for these holders which have replaceable copper jaws, four-line contact for electrodes, and an all-copper path for the welding current. They are made of structural steel for maximum strength



Lincoln Electric Co. 600-Amp. Metal Electrode Holder

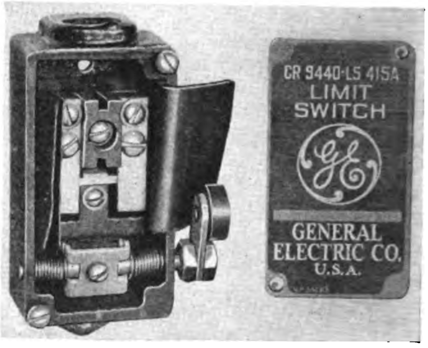
and light weight, and are well balanced. These holders have an insulated and ventilated handle and shield for protecting the operator's hand.

Limit Switch

A SMALL limit switch has been designed by the General Electric Co., Schenectady, N. Y., to meet the requirements of the machine tool industry and other manufacturers for their control circuits. This switch can be used for stopping carriages at the end of the travel, bailing machines, door-opening limits and for other applications where normally-open or normally-closed contact is required.

The switch is cast iron, is arranged for conduit connection and is designed to be dust-tight. The contacts may be either normally open or normally closed, although the switch as shipped by the manufacturer is normally closed. To change over for normally-open operation requires but the removal of a few screws, the reversing of a finger block and the replacing of the screws.

The operating arm of the switch can be set at any angle by loosening the



Small Limit Switch Manufactured by the General Electric Co.

nuts on the operating shaft, adjusting the arm and then tightening the nuts. If it is desired to use the operating arm on the other side of the switch, a form can be furnished with the arm mounted on that side.

The following ratings are given to cover the switch, providing it is opened approximately ¼ in: 2 amp. at 125 volts, 1 amp. at 250 volts, and 0.4 amp. at 600 volts.

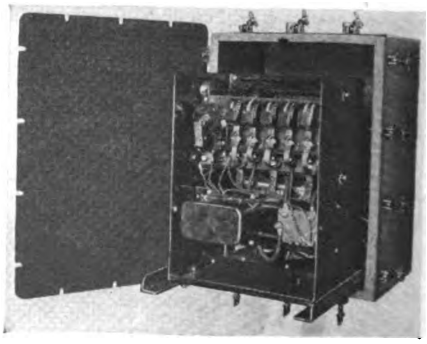
Dust-Tight Compensator

A SMALL automatic compensator has been designed by the General Electric Co., Schenectady, N. Y., to be used in places where dust is prevalent as in grain elevators, coal crushing plants, and other similar places. This device is for low voltage, and is inclosed in a boiler plate case. The compensator has been given the General Electric designation CR-7051-J-2.

A standard automatic compensator is used in the construction, but the usual conduit box, wall support and top and front covers are omitted. The boiler plate case in which it is enclosed is made up as a unit with angles on which the compensator may be slid in or out. When the compensator is in position the angles can be raised to a vertical position, thus allowing the front door to close.

The boiler plate case is made up of ¼-in. plate. The front cover is held down by 14 wing nuts and clamps against a vellumoid gasket on the case. An extra cable clamp is furnished with the compensator to hold the cables and to take the strain off the terminal board when the compensator is put into and taken out of the case.

Small G. E. Dust-Tight Compensator.



Practical Books
for your personal library

Every man who aspires to larger responsibilities should build up a professional library containing carefully selected volumes on subjects related to his work. Copies of the books which are reviewed here may be obtained from the publishers mentioned.

NON-TECHNICAL CHATS ON IRON AND STEEL—By LaVerne W. Spring, Chief Chemist and Metallurgist, Crane Co. Published by Frederick A. Stokes Co., 443 Fourth Ave., New York, N.Y. Cloth; 5½ x 8 in.; 465 pages; 342 illustrations. Price $4.

The present volume is the second edition of this work, which has been brought up to date by the incorporation of considerable new matter and the revision of much of the material in the first edition.

The purpose of the book is to present in a simple way, that is authoritative and yet free from hard-to-understand technicalities, the more important facts relating to the metallurgy of iron and steel. Beginning with an interesting chapter on the early history of iron and iron working, the raw materials used in smelting iron are discussed. This is followed by a description of the construction and operation of the blast furnace and the processes employed in producing wrought, cast and malleable iron, alloy and high-speed steels, and so on. The processes involved in the manufacture of wire, rods, pipe and other products are discussed in separate chapters. The crystal structure of iron and steel under different conditions of treatment is well illustrated by many micro-photographs.

The layman who would like to know more about the manufacture and properties of the most useful metal known to man will find this book admirably suited to his purpose.

REPAIR SHOP DIAGRAMS AND CONNECTING TABLES FOR INDUCTION MOTORS—By Daniel H. Braymer, Consulting Engineer, and A. C. Roe, Industrial and Insulation Engineer, Renewal Parts Engineering Department, Westinghouse Electric & Manufacturing Co. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N.Y. Cloth: 6 x 9 in.; 232 pages, 210 illustrations. Price $2.50.

The object of this book is to furnish repairmen and armature winders with practical step-by-step instructions on laying out of coils for induction motor windings and connecting the coil groups in proper sequence for different types of windings used in two- and three-phase motors having from 2 to 24 poles. The information presented can also be used when reconnecting the coil groups to satisfy changes in voltage, number of phases, frequency, or speed.

Each diagram in this book is a practical shop drawing, the proper connections for the ends of all phase groups of coils being indicated so that they can easily be followed by the winder when making the connection. In addition, the diagrams are accompanied by tables that give the number of coils in the different phase groups and the markings for the ends of these groups as indicated in the diagrams, to show the differences in marking for the ends of phase groups in various types of windings.

STANDARD WIRING—For Electric Light and Power—By H. C. Cushing, Jr. Published by H. C. Cushing, Jr., 15 West 55th Street, New York, N.Y. Leather; pocket size; 496 pp.; 391 illustrations; 91 tables. Price $3.

In the 1927 (33d Edition) of Cushing's "Standard Wiring for Electric Light and Power" the author has endeavored to set forth the essential requirements for safe and efficient wiring and construction for electric light, heat, and power. Every suggestion and recommendation is in accordance with the latest edition of the National Electrical Code and the latest engineering practice. There are many explanatory and helpful notes, illustrations, definitions, and tables for the guidance of the man who does the work.

This handbook covers the subjects of inside and outside wiring, generators and motors, storage batteries, illumination, and special types of wiring such as in garages, theatres, moving picture houses, electric range, heater, and radio wiring. Among the added features in this 1927 edition is a complete treatise on the "Red Seal" wiring plan, giving complete specifications, and new chapters on illumination and house wiring.

This well-known manual seems to become more useful and usable with each new edition.

UNDERGROUND SYSTEMS FOR ELECTRIC LIGHT AND POWER—By T. C. Ruhling, Vice-Chairman, N.E.L.A. Underground Systems Committee. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N.Y. Cloth, 6 x 9 in.; 346 pages; illustrated. Price $4.

This book had its beginnings in a few cost records which the author made in the course of his work on underground electric conduits. These notes were later expanded into articles that appeared in various technical journals.

The scope of this book is well indicated by the following chapter headings: Underground Conduit Construction; Laying Fiber Conduit; Tile-Duct Construction; Manhole Construction; Underground Construction Cost Data; Transmission and Distribution Conduits; Underground Transmission and Distribution; Underground Cable Installation; Underground Street-Lighting Systems; Installing Submarine Cables; Cable Splicing; Fireproof Underground Cables; Fault Location.

Out of his wide experience in underground work the author has produced a treatise on this subject that will be of interest and value to engineers, construction foremen and all others who are concerned with the layout and installation of underground electrical systems.

SWITCHING EQUIPMENT FOR POWER CONTROL — By Stephen Q. Hayes, General Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N.Y. Cloth, 6x9 in.; 556 pages; illustrated. Price $5.

The present volume is the second edition of this book, and has been made necessary by the important developments and changes in both design and practice in the application of switching equipment that have been made during the past few years.

Owing to the comparatively recent introduction of European switching equipment it was deemed desirable to include in this edition a description of certain European equipment and practices that appear likely of adoption in this country.

The arrangement of the subject matter has followed the plan of first describing switching equipment in the order in which the various devices were developed. This is followed by a discussion of the main connections desired in a power plant and the methods of obtaining the maximum reliability and safety with the minimum outlay. Switchboard panels, control desks, and the like, are considered next, with the location of the circuit breakers, bus structures and other equipment, and the general arrangement of that part of the power plant devoted to switching equipment.

The main object of the book is to give the switchboard operator information that will help him to keep the equipment in his care in the best operating condition, by explaining its functions and capabilities.

This book will also help students of electrical engineering to obtain a better understanding of the relations between the switching equipment and the apparatus which it controls.

Consulting engineers and operating men will find in it information that will give them an understanding of the functions and limitations of the various devices treated and facilitate the selection and application of equipment that is suitable for the service requirements.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Steel Shelving—Circular No. 1277, recently issued, describes and illustrates the Universal line of steel shelving and cabinets.—Universal Fixture Corp., 135 W. 23d St., New York City.

Hydraulic Jacks—"The Big Lift for Your Business" is the title of the brochure which introduces the Blackhawk line of hydraulic oil-power jacks. These jacks are made in several styles with capacities ranging from 1½ to 75 tons.—Blackhawk Manufacturing Co., Milwaukee, Wis.

Transformers—An illustrated description of Wagner HE type of single-phase distribution transformers and tables of dimensions and capacities are contained in Bulletin 148.—Wagner Electric Corp., St. Louis, Mo.

Direct-Current Motors — Bulletin 200 describes and illustrates Reliance Type T heavy-duty direct-current motors.—Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio.

Threadless Fittings—A series of folders has been issued describing and illustrating the Kondu boxes and couplings manufactured by this company—Erie Malleable Iron Co., Kondu Division, Erie, Pa.

Magnet Wire—Catalog No. 27, covering the entire line of Maring magnet wire is now being distributed by this company. It contains tables, data and other helpful information for magnet wire users.—Maring Wire Co., Muskegon, Mich.

Die Stocks—Booklet No. 19 contains an illustrated description of the Beaver line of die stocks, pipe cutters and power drives.—The Borden Co., Warren, Ohio.

Films—The Gas Products Association has recently completed two reels of films illustrating the oxy-acetylene welding and cutting process. A limited number of prints of these films are available and may be had by making application to the association secretary. —Gas Products Association, 140 So. Dearborn St., Chicago, Ill.

Worm Gears and Drives—Bulletin E devotes 32 pages to an explanation of the construction and application of data on Type WT Fawcus Timken-bearing worm-drive speed reducers. Several pages are devoted to engineering data including dimension outlines, ratios, efficiency and horsepower ratings of these units.—Fawcus Machine Co., Pittsburgh, Pa.

Portable Elevators—Bulletin 90C describes the new model M silent-chain spur-gear drive as applied to electric portable elevators.—Revolvator Co., 336-352 Garfield Ave., Jersey City, N. J.

Electric Heating — Catalog C describes and illustrates electric heat control and resistor units manufactured by this company.—Acme Electric Heating Co., 1207-1223 Washington St., Boston, Mass.

Flexible Coupling—Bulletin 627 illustrates the construction and operation and gives ratings and dimensions of the new Nicholson all-metal, lubricated flexible coupling.—W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa.

Electric Hoists—The 28-page bulletin 71-A is an illustrated and descriptive catalog of Shepard floor-operated electric hoists.—Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.

Welded Pipe Lines—A well-illustrated booklet describes a number of long pipe lines with Oxwelded joints.—The Linde Air Products Co., 30 E. 42nd St., New York, N. Y.

Insulating Compounds. — Bulletin 696 is a supplementary catalog giving the characteristics and uses of various Mitchell-Rand insulating compounds.—Mitchell-Rand Mfg. Co., 18 Vesey St., New York, N. Y.

Carbon Brushes.—An 11-page illustrated catalog gives a description and instructions for ordering Carenco brushes for motors and generators.—Carbon Engineering Co., Eighth Ave. & Morgan St., Milwaukee, Wis.

Air-Cooled Transformers — Bulletin 527 illustrates the various types and gives specifications together with wiring diagrams for Trester air-cooled, dry-type transformers for lighting and other similar service.—Trester-Service-Electric Co., 55 E. Wells St., Milwaukee, Wis.

Speed Reducers—Catalog 26 devotes 96 pages to illustrating numerous applications and to giving dimensions and other engineering data regarding the Jones spur gear and worm gear speed reducers.—W. A. Jones Foundry & Machine Co., 4430 W. Roosevelt Road, Chicago, Ill.

Ground Rods — A folder gives the advantages of using Copperweld ground rods and ground wire attachments for permanent, low-resistance earth grounding.—Copperweld Steel Co., Braddock P.O., Rankin, Pa.

Outboard Bearings—A circular describes and lists the sizes of the new standardized, adjustable outboard bearings manufactured and distributed by this company. — Boston Gear Work Sales Co., Norfolk Downs, Quincy, Mass.

Fire Extinguisher—A circular describes the F-R-X gallon type carbon tetrachloride fire extinguisher for electrical and other fires. This unit contains a pressure tank for discharging the extinguishing liquid. — Foamite-Childs Corp., Utica, N. Y.

Factory Trucks — A circular describes and illustrates a line of four-wheel box, open-side, and flat-top steel trucks manufactured by this company.—Angle Steel Stool Co., Plainwell, Mich.

Crawler — Bulletin B-10 illustrates applications and construction features of the Link-Belt all-purpose crawler which can be converted and used with shovels, drag-lines, cranes and so on.—Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

Condulets—Folder 50 illustrates and gives the various types of the new Crouse-Hinds Obround Form 7 condulets and condulet fittings with Wedge-Nut fasteners. — Crouse-Hinds Co., Syracuse, N. Y.

Speed Control—A circular covers the Reeves electric remote control speed regulation for the Reeves variable speed transmission unit.—Reeves Pulley Co., Columbus, Ind.

Unit Heater — A 16-page catalog illustrates the construction of the hiJet unit heater with the Wedge Core radiator and engineering data for their selection and installation.—The Herman Nelson Corp., Moline, Ill.

Power Transmission — A recent issue of *The Labor Saver*, distributed monthly by this company, describes the construction and operation, illustrates applications, and gives engineering data on the JFS variable speed transmission and the S-A Speeducer spur-gear speed reducer. — Stephens-Adamson Mfg. Co., Aurora, Ill.

Insulating Varnish — A 12-page illustrated booklet discusses the use of insulating varnish for impregnating coils, with helpful suggestions on how to use it. — John C. Dolph Co., 168 Emmet St., Newark, N. J.

Volume 85 New York, October, 1927 *Number* 10

INDUSTRIAL ENGINEERING

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

Application and Operation of Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

D. H. BRAYMER
Consulting Editor
A. J. WHITCOMB
Contributing Editor

G. A. VAN BRUNT, *Editor*

F. E. GOODING
G. H. FAIRBANKS
Associate Editors

Contents

Departments

The Purpose of This Number

THERE are two very practical purposes intended for this "Hard Drive" number of INDUSTRIAL ENGINEERING.

One of the purposes is to place before each reader the means of solving the problem of the difficult "drive" that he frequently encounters in the mechanical transmission of power in his plant.

The second purpose is to aid industry to cut down the tremendous waste of power now incurred through improper selection, installation and maintenance of its mechanical transmission equipment.

Both of these purposes, we believe, will be well served by this issue, because of the "case" method of presentation employed. For it is through such presentation of the practical experience of many others that one can best and most quickly acquire a knowledge of the fundamentals of correct practice.

The material for this number is drawn from many and varied sources. It represents the best practice of the present day in mechanical power transmission. INDUSTRIAL ENGINEERING is gratified to present this number to its readers as part of its plan to serve and uphold those important plant services that keep the wheels of industry turning.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

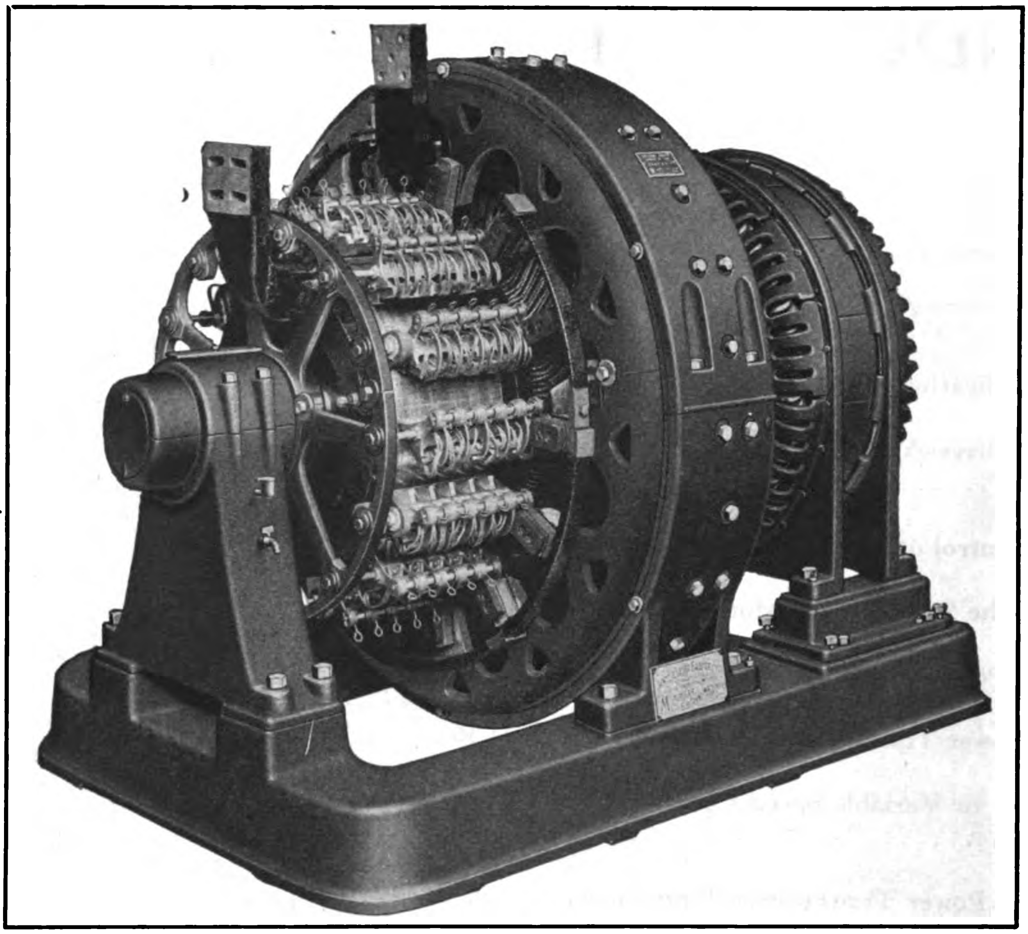
JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

WASHINGTON, National Press Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4
Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

NEW YORK District Office, 285 Madison Ave.
Cable Address: "Machinist, N. Y."

Publishers of
Engineering News-Record
American Machinist
Power
Chemical and Metallurgical Engineering
Coal Age
Engineering and Mining Journal
Coal Age News
Electrical Merchandising
Ingeniería Internacional
Electric Railway Journal
Bus Transportation
Construction Methods
Electrical World
Radio Retailing
Industrial Engineering
Electrical West
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

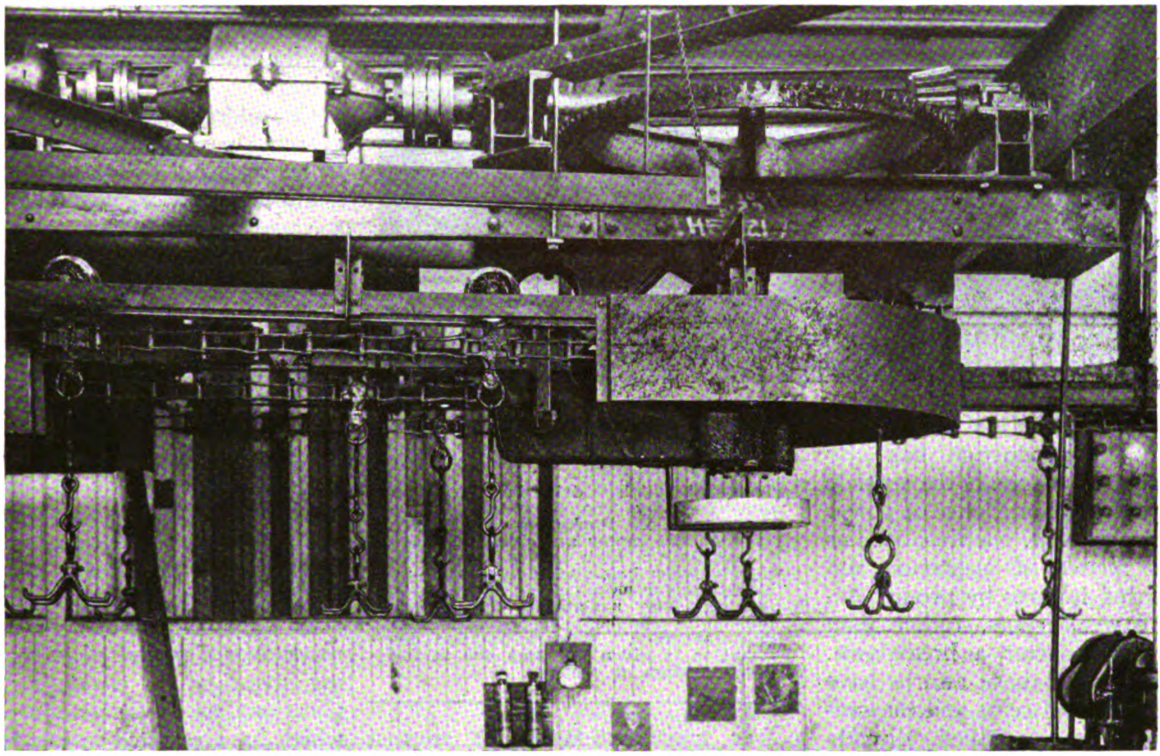
The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.



INDUSTRIAL ENGINEERING

Application and Operation of
Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

Volume 85 New York, October, 1927 *Number 10*



Crankshaft conveyor 2,560 ft. long in large automobile plant driven at 16 ft. per min. This conveyor has 11 horizontal and vertical turns. The reduction is obtained through a 142:1 Palmer Bee mill-type reducer, and a pair of bevel gears.

Trends in application of

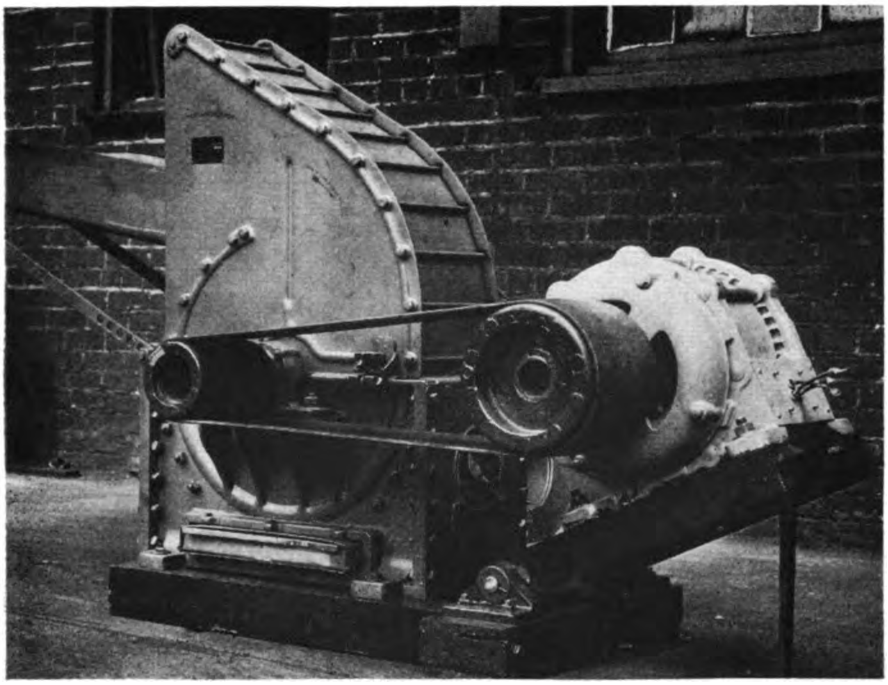
Power Drive Equipment

with details of recent improvements made in design

By FRANK E. GOODING
Associate Editor, Industrial Engineering

IT MIGHT truly be said that the importance of power transmission is just beginning to get full recognition among industrial operating men. When competition between industrial plants was not so keen as it is today, little attention was paid to power transmission problems. The entire cost of this item was small in comparison with many of the other expenses. Today, industrial competition, particularly in the older and well-established industries, has forced cost reductions in every phase of manufacturing and operation. The largest items of expense, labor and material, were attacked first, but many industrial plants are now delving into and reducing the lesser items of expense.

Power transmission and plant operation and maintenance costs have received particular attention, therefore, not only because of the possibilities of cost reduction but, also, because of the importance of providing reliable and continuous power service. Failure of a machine or its drive means interrupted production. Some plants, which have spent thousands of dollars in installing new machinery to improve production, but tried to save a few dollars on the drive or its control, have found that a production unit, like a chain, is no stronger than its weakest link. If the drive is improperly selected, installed, or maintained, or any part of it fails, the machine is put out of production.



A new development in short-center gravity belt drives applied to a hammer-type feed mill.

This Uni-Pull belt drive has just been announced by The Rockwood Manufacturing Co. Rockwood pulleys are used on the motor and driven pulleys to maintain a high coefficient of friction between belt and pulleys and the hinged motor mounting is so designed that gravity maintains the proper tension in the belt, according to the manufacturers. A more detailed description is given on page 498 in the New Equipment section.

Realization of the importance of continuous production has also brought about a change in the attitude towards general maintenance of power drives. As a result, maintenance has become a matter of inspection and prevention of failures by prompt detection of weak spots, rather than making repairs after a breakdown.

The results of these efforts have paid in dollars and cents and the savings made have applied directly toward the profits. The saving of a dollar in operating cost is equivalent to the addition of many dollars (depending upon the percentage of profit) of new or additional business.

Among the most noticeable efforts toward the reduction of production and operating costs have been the installation of newer and better types of equipment, with particular attention to the bearings and other wearing parts, as well as their lubrication. In addition, there has been a noticeable attempt to see that drives are properly loaded. Manufacturers of machinery usually recommend a powering that will be satisfactory for the heaviest load it is possible to place upon the machine; that is, they try to make the drive as strong as the machine. In case the machine is to be used for a variety of large and small work, it is always best to power it according to these recommendations. However, in many lines of manufacturing the machines will never be more than partially loaded. In such cases it is not only unwise but uneconomical to provide a large excess capacity in the drive. Accordingly, in many plants steps have been taken to measure the power consumption under normal load and provide a drive ample for the normal operating conditions.

The advantages of this plan are well shown in an installation where a study of the operating problems and power requirements indicated that a belt 1 in. narrower than the size originally recommended by the manufacturer could be used on an entire battery of machines. As this was a new installation the use of the narrower belt saved considerable in the cost of the original installation.

The close control which some operators keep over the drives under their supervision is well shown by the practice of one Chicago industrial plant. In this plant a large proportion of the machines are individually driven by motors of 10 hp. and larger. Whenever a new machine is placed in service a graphic meter is used to obtain the power consumption of the motor when disconnected, with the motor connected and the machine running idle, and when operating under load.

This record is filed away for reference and whenever that drive gives trouble a new record is made which shows almost at once whether additional load has been put on the machine or whether wear, or a defective gear or other mechanical part is responsible for the trouble. In this way, it is very easy to separate the motor from its drive and trace the cause of trouble. In many cases, troublesome drives are rather baffling because of the difficulty in locating the cause, particularly as the trouble frequently shows up in the motor when the cause lies in the machine or some of the mechanical elements of the drive.

Considerable study is also being given to power transmission and related problems by various interested manufacturing organizations and associated bodies. This should be of considerable benefit to industrial operating men. The constructive program that has just been undertaken by the American Gear Manufacturers' Association is one example of this. This organization, composed of gear manufacturers, has made extensive studies in the standardization of gears and investigations into gear-tooth loading and its effect on design, with particular attention to the non-metallic gear materials.

The Leather Belting Exchange has also done effective and important work over a period of years in making investigations on leather belt applications, as well as studies of belts which have resulted in improvements in their manufacture.

The American Engineering Standards Committee has begun investigations covering the establishment of standards which, although it may take considerable time for the full benefit to be obtained by industrial users, nevertheless, have extensive future possibilities for simplification of industrial drive problems. One of these investigations, for example, is a study of the possibility of standardizing the speed of the driven shaft on machines of various types. It is hoped that it will be possible to standardize these speeds, so that machines may be connected up much more easily. This organization, with the co-operation of interested societies and manufacturing associations, has also been working on standards for keyways, shaft sizes, standardization of motor frames, and other problems of far-reaching importance to industrial men.

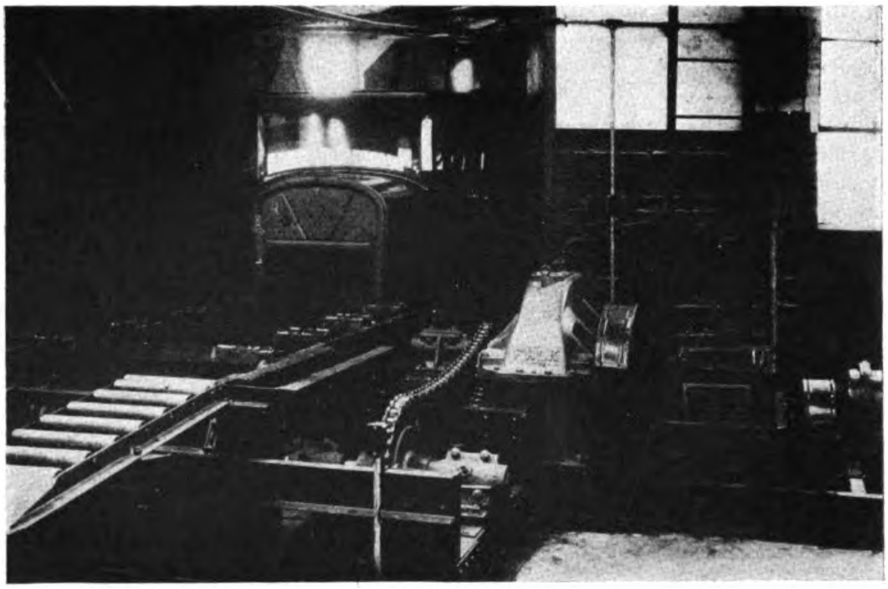
The recently organized Power Transmission Association, composed of manufacturers of power transmission equipment, is taking steps to provide similar valuable assistance to industrial operating men. One of the

most important of these services that has been announced will be the preparation of a Power Transmission Handbook to contain authentic and reliable data on the selection of power transmission equipment. This work will be carried on by a group of experienced engineers from various industrial plants and should be of great aid to industrial men.

Other trends and developments in power transmission activities will be discussed under their respective headings.

Group and Individual Drives—One of the important operating problems which is to be given considerable attention by the Power Transmission Association is the subject of the relationship and application of group and individual drives. These investigations will take up the subject of first cost, operating cost, convenience, reliability, and operating advantages and disadvantages. Operating men will welcome such an investigation.

During the past year several new plants have been laid out to operate largely on the group drive principle. This is exceedingly interesting because the tendency in these industries had been very strong toward individual drive. These isolated instances, however, can hardly be taken as a distinct trend. A recent example of a large group drive was the installation of an engine-driven lineshaft in a large, New York paper mill. Each of the 16 heaters in a group was connected to the lineshaft by a 14-in. belt. A 1,700-hp. compound-condensing engine drives this shaft through a 76-in., four-ply, Rhodes Tannate belt. This is probably one of the largest single group drives (from the standpoint of power transmitted) recently installed.



Body conveyor drive in new Pontiac automobile plant.

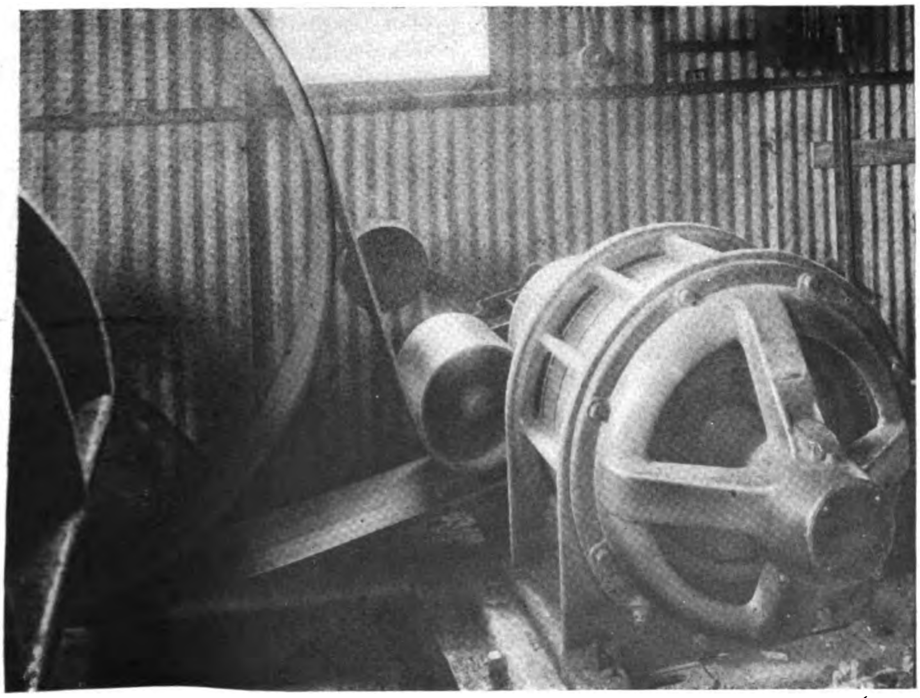
In this drive the motor is connected to a Reeves variable-speed transmission driving a Falk herringbone speed reducer with an outboard bearing carrying the sprocket for the roller chain connection to a shaft on the conveyor. This installation was made by Mechanical Handling Systems, Inc., Detroit, Mich.

Lineshafts—In the article, "Trends and Practices in the Use of Power Drive Equipment," which appeared in the October, 1926, issue of INDUSTRIAL ENGINEER, considerable attention was given to the tendency toward standardization of lineshaft sizes. This tendency has increased considerably during the past year, especially where plants have decided to install ball or roller bearings either on lineshaft hanger boxes or in pillow blocks. A standard shaft diameter is selected and all new shafts purchased accordingly, together with the standard bearings for the installation. In applying this standardization, there seems to be a tendency toward allowing rather ample rating of the standard shaft selected.

Many times it is not realized, until too late, that it is a mistake to install lineshafts, hangers and bearings of the smallest possible size for the actual loading which will be placed on them at that time. Later, when rearrangement of the machines has forced pulleys midway between hangers or an additional machine load necessitates the transmission of larger amounts of power, it is discovered that the shaft can not handle the new requirements without excessive vibration. One instance was noted recently where in the interval between when the drive was laid out and the equipment received, sufficient additional equipment had been scheduled for the group to give the shaft an actual overload of 20 per cent. In case a shaft of ample size is to be loaded more heavily, it is a simple matter to install a larger motor. If the shaft is too small, however, the load must be cut down, re-arranged into smaller groups, or a new shaft installed.

Flexible idlers are helping to solve many difficult drive problems.

Here a 40-hp. motor is driving a pulverizer on 5-ft. centers, using a Pulmax drive. The belt speed is 6,000 f.p.m. This is one of five pulverizers that were originally driven by open belts operating on 17-ft. centers. By changing the layout as shown here belt trouble has been reduced and the floor space formerly required by the drive has been greatly reduced.



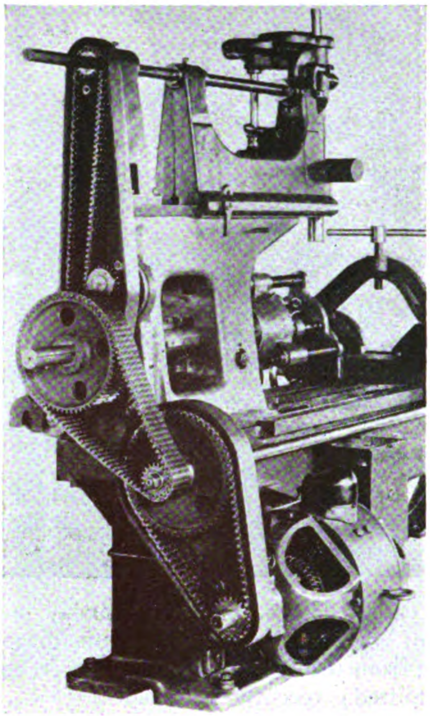
Most operating men understand and appreciate the importance of good millwrighting. Although false economy, it has been considered necessary in some cases to slight this important work to reduce the cost of installation. This skimping has usually taken the form of increasing the distance between hangers, inadequate bracing in the groundwork, or the use of too light a hanger.

Bearings—Studies of operating problems and causes of interruptions to service have indicated that one of the most vulnerable points on ordinary machines or other equipment lies in the bearings. Better lubricants and improved methods of applying them have had some effect in making bearings more reliable, but the older type of plain bearings were not designed so that effective use can be made of the better facilities for lubrication now available.

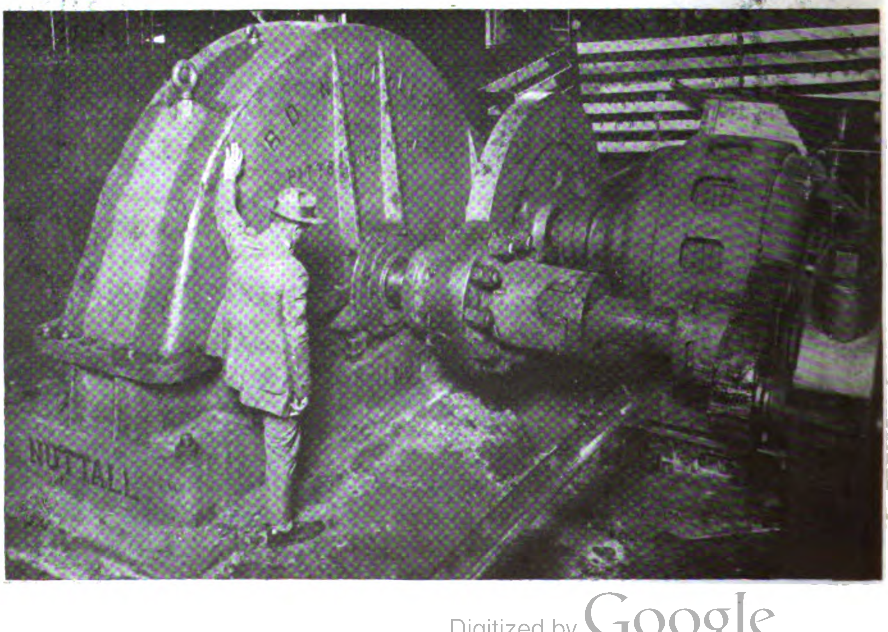
In the previously-mentioned analysis of power transmission developments, in the October, 1926, issue, the increasing use of anti-friction ball or roller bearings in lineshaft hanger boxes was emphasized. The past year has been marked by a growing tendency to use anti-friction bearings in different forms of power transmission equipment. This has been brought about largely by a recognition of the advantages obtainable through their use. Again, bearing engineers have successfully solved several problems in the application of such bearings to various types of power transmission equipment to which such application was formerly considered impracticable, for various reasons.

The net result of these factors has been a considerable increase in both the number and variety of applications to different types of power transmission equipment. These include gear drives of different kinds, and equipment used in connection with lineshafts, such as pillow blocks and shaft hangers.

In the modernization of industrial plants it has become common practice when rebuilding a machine or drive, to install pillow blocks with ball or roller bearings, particularly on the drive shaft. The use of these anti-friction bearing pillow blocks has accomplished much toward improving the operation of short shafts, jackshafts, and driveshafts which are a part of the machine. These bearings have better facilities for lubrication, which not only decreases the amount and, therefore, the cost of the lubricant but also the cost of its application and of the necessary servicing of the bearings. More reliable lubrication and better bearings have resulted in less frequent interruption from bearing failures, more reliable operation, and saving in power.



Method of maintaining tension on silent chain drives with fixed centers.
The Link-Belt automatic idler and back-chain, which have been used on automotive front-end drives, have been applied to machine tools to maintain tension and take up for wear. This automatic take-up is used on the upper vertical chain on this machine.

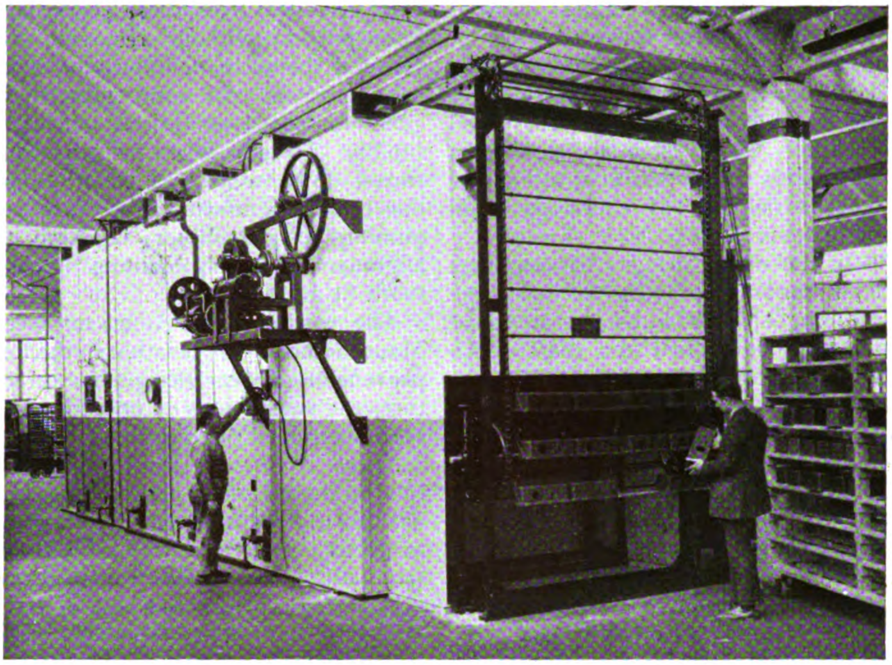


Single helical gear reduction on steel-mill drive.
This 350-hp., R. D. Nuttall unit is equipped with Timken tapered roller bearings on pinion and gear shafts. The method of mounting the bearings to provide for thrust and expansion of the shaft is explained in the text.

Some of the more outstanding examples of different types of equipment to which these bearings have been applied may merit a more detailed description, if for no other reason than to show how the difficulties in connection with their application have been overcome.

A typical example is the 350-hp., single-helical speed reducer shown in the accompanying illustration, which was built by R. D. Nuttall Company, Pittsburgh, Pa., and recently placed in service. In this installation, the pinion shaft has a four-bearing mounting; that is, there are two bearings, mounted back to back at each end of the shaft. Those at one end are given a press fit on the shaft, and arranged to hold the pinion in rigid alignment with respect to the main gear. The bearings on the other end are mounted so as to allow the shaft to float through them, partly to take care of shaft expansion, and partly to allow the pinion to locate itself with respect to the gear. The bearing mounting of the gear itself consists of a single bearing on each end of the shaft, the cone being a press fit on the shaft, and the cups permanently located by the housing. Timken tapered roller bearings are used throughout. Expansion and thrust have been two of the difficult problems involved in the use of anti-friction bearings on such machine.

Babbitted bearings are still used in many plants. For their replacement or renewal considerable care must be exercised in melting the babbitt, particularly where special alloys are used, because a temperature that is too high or too low does not give the proper results. For this reason many plants are using electric melting pots with temperature indicators or con-



Push-button controlled variable-speed drive on an oven.
This continuous oven is used for baking the finish on Atwater Kent radio cabinets. Variable speed is obtained through a Reeves transmission by push-button control.

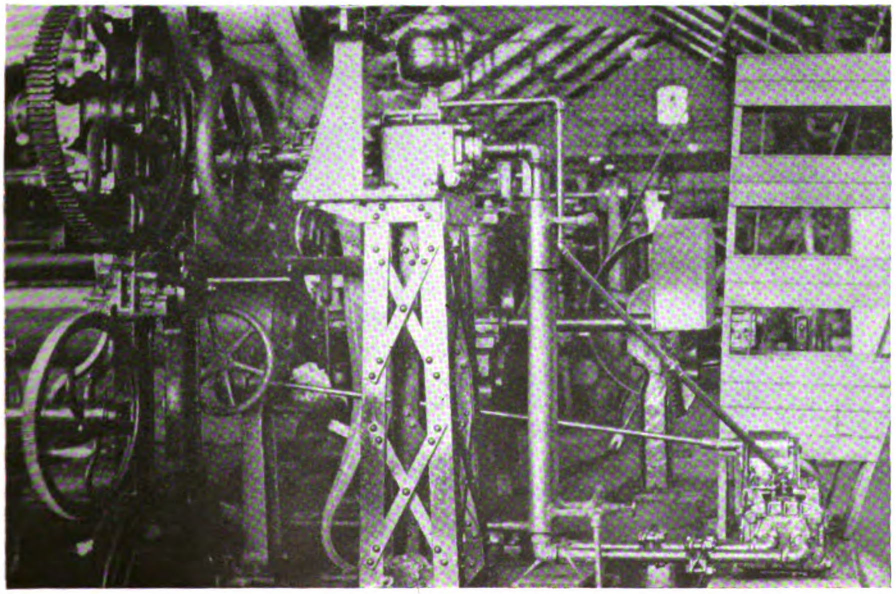
trol for melting the babbitt or other bearing alloys.

Belts—Operating men quite generally report an increased use of cemented endless belts on main drives, particularly on belts 6 in. and wider and in some cases belts above 4 in. in width. In some plants endless belts are used only where there is provision for take-up. It is interesting to note that improvements have been made in both the Clipper and the Detroit belt lacing machines. Each has brought out a lacer of increased size for the metallic lacing of belts.

An interesting new type of belt that is being tried out on hard drives in a wide variety of industries consists of a combination of leather and fabric with plies of each cemented together. This belt is sold under the trade name of Tex-Tan and is manufactured by Wayne Belting and Supply Co., Fort Wayne, Ind. Belts of this construction are claimed to have the advantages of both fabric and leather belts.

There has been a very much increased application of short-center or flexible-gravity idlers to belt drives. Although these were originally used on difficult drives or to compensate for extremely small pulley diameters, they have now come to be considered as a regular part of a belt installation, particularly where the driving pulley is small. The use of gravity idlers has overcome many of the operating problems connected with such drives because the idler gives much greater contact on the small pulley and at the same time decreases the necessary tension in the belt and the pressure on the bearings. These idlers are still almost a necessity on difficult belt drives, because, if properly applied, they get all possible driving capacity out of the belt. Recently some of these idlers have been used on quarter-turn belts.

Variable-speed drives are widely used on paper machines.
This illustration shows a Universal Hydraulic Variable Speed Gear driving a paper cutter. The pump or A-end of the gear is mounted on the floor and driven by a belt from the variable-speed line of the paper machine. Oil is piped from it to the B-end which is mounted on the pedestal and connected to the cutter shaft. The speed of the B-end is controlled by the handwheel shown just in front of the lower size press roll. Use of this drive has made it possible to reduce the amount of stock left for trimming from about $\frac{5}{8}$ in. to $\frac{1}{8}$ in. per cut.



The Texrope drive, which consists of several special-type V-belts running in grooved pulleys, is being used in a number of installations of 100 hp. rating and over. The article beginning on page 484 of this issue contains a number of interesting applications of this drive in a cement plant where it is subjected to severe service, due to abrasive dust in the atmosphere, heat and shock loads.

Chains—Users of chain drives are realizing that more careful consideration must be given to the service conditions when laying out such drives. Underrating, the failure to take into consideration severe operating conditions, and misalignment, are probably responsible for the larger proportion of operating difficulties that have occurred in connection with various chain drives.

The increasing use of silent chain drives on machine tools when center distances are fixed has led to the use of an automatic idler and vibration damper, similar to that used on automobiles, because some provision must be made for taking up any wear or slack and maintaining tension on the chain. A special idler sprocket for maintaining this tension has been announced by the Link-Belt Company. An application of this device is shown in one of the illustrations.

Flexible Couplings—There appears to be a decrease in the former practice of many plants of making their own flexible coupling from a pair of flange couplings by placing staggered pins on the faces and interweaving a short, endless piece of belt on the pins. This home-made coupling works fairly well on slow speeds and light loads,

but it is not balanced unless by accident. Much better service can be obtained by selecting a suitable flexible coupling from the variety of types available from manufacturers and dealers. More standardization in shaft sizes would permit stocking and quicker delivery of couplings from these sources.

In the newer designs of couplings it is common practice to make the coupling able to withstand any load that may be applied to a shaft which will fit the maximum permissible bore of the hubs. This practice, it is claimed, makes the coupling as strong as the shaft, and so it cannot be overloaded.

Several types of lubricated flexible couplings have been brought out and, in addition, practically all manufacturers of couplings have improved their designs within the past few years to simplify the construction, to strengthen the unit, and increase reliability. There has been an increasing tendency towards the direct application of a motor, gear, or speed reducer to a shaft by direct connection through a flexible coupling. On speed reducers, for example, couplings are usd on both high- and low-speed shafts (when direct connected to the shaft) instead of only on the high-speed shaft, as was common practice when the function of the flexible coupling was not so well appreciated.

Clutches—Although a few manufacturers have improved or redesigned their clutches to meet modern high-speed, heavy-duty applications there is still considerable opportunity for improvement by designing less complicated and more rugged units. Because of the difficulty of obtaining clutches suitable for modern power transmission requirements, many operators try to arrange equipment so as to eliminate the necessity of using a clutch. For example, hydraulic variable-speed transmissions which can be used to obtain any speed from zero to full input speed have been installed to obtain not only the variation in speed desired but also to take the place of a clutch and throw the machine out (zero speed) and pick up the load gradually.

Gears—Items of particular interest concerning the application of gears are the wider use of non-metallic gears and the increased use of heat-treated, tool-steel pinions on drives subject to abrasive atmospheres or excessive wear.

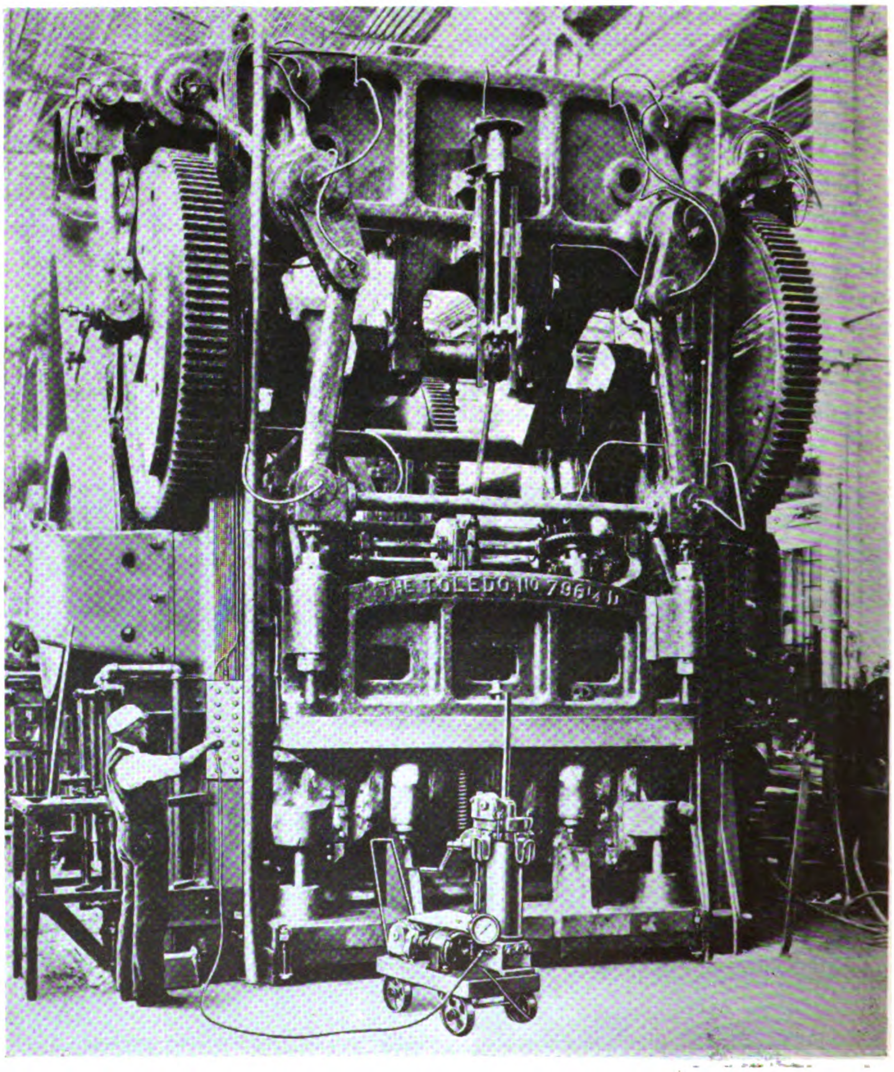
Gear users have not fully appreciated the advantages or purpose of using non-metallic gears on noisy or hard drives. Often these gears have been put on without removing the cause of the noise, or improving service conditions. In some cases, these gears improved conditions but wore rapidly. Usually, when the cause was traced down wear was found to be due to misalignment. Users are beginning to pay closer attention to alignment and to obtaining perfect tooth fit and clearance.

The work of the American Gear Manufacturers' Association in the improvement of gear design, manufacture, and suggestions on operation has been mentioned previously.

Speed Reducers—It is interesting to note the extensive redesigning that has taken place in the past few years in speed reducers, particularly those of the worm type. Practically every manufacturer of worm-gear speed-reduction units has brought out new and improved models within the past year or two, or added vertical units to his line. In most cases the improvements have included a much larger case to hold a greater quantity of oil and also to provide larger radiating surface to cool the oil, special alloys for both worm and gear, which in some cases are heat-treated and ground, and ball, roller, or special bearings. In some designs pumps or other facilities have been provided for lubricating the worm when it is placed above the gear. There is an increasing tendency to use an outboard bearing where a pulley or sprocket is mounted on the slow-speed shaft.

Some progress has been made in the introduction of standardized worm and other reduction gear units in certain standard reductions and the carrying of these in stock by some of the companies or their distributors. This includes some small double-reduction worms for high reductions of 100 to 1 and larger, in rating of 1 hp. and under. Link-Belt Company

New type of centralized control for lubrication of large machinery.
Individual pipe lines from the bearings terminate at a central station. The lubricant is forced under high pressure to the bearing by Dot hand guns or portable power-driven compressors. This machine has a production value of $30 per hour. It formerly required about an hour for two men to climb over the machine and fill and screw down the 56 grease cups. Now it is not necessary to stop the machine for lubrication.



has brought out the Caldwell speed reducer which consists of a fixed reduction ratio gear unit to be direct-connected to the load and standard chains and sprockets which are carried in stock in various branch warehouses are used to connect the motor to the reducer and thus obtain any of a number of standard reductions. These units are especially designed for use on elevators and screw conveyors. The Cincinnati Tool Steel Gear & Pinion Co. has brought out a mill-type speed reducer with heat-treated gears, especially adapted for hard service in steel mills, cement plants, and other similar industries. In addition, there have been extensive development and redesigning of several makes of mill-type and herringbone speed reducers.

It is reported that paper mills are using a number of speed reducers on various drives to give a more direct reduction and closer connection. Also, in many lines of work a speed reducer is now connected directly to a lineshaft through a flexible coupling, thus simplifying the drive, by eliminating a gear or chain connection.

Variable Speed Transmissions—Although variable speed drives are not new, industry still has many opportunities for adopting them. Almost any machine that is used on a variety of work has a best operating speed for each type of work. It is difficult to obtain this variation in speed except through the use of an electrical, mechanical, or hydraulic variable-speed device. The manufacturers of mechanical and hydraulic variable-speed transmission units have made considerable improvement in design recently to improve operation. The Reeves unit, for example, can now be provided with a motor-driven speed control that can be operated to increase or decrease the speed from push buttons. The speed-control motor is independent of the start or stop control of the motor driving the variable-speed transmission. Improvements have also been made in the Reeves belt. Both the Reeves and the Lewellen variable-speed transmissions may be obtained with anti-friction bearings.

Manufacturers of hydraulic transmissions have also made considerable development and improvement in their equipment and have applied them to a much wider field of industry. The Oilgear, for example, is used on numerous applications in the machine-tool and other special fields. Some of these applications are quite new and are being studied preparatory to future announcements of the operating results. Applications of the Universal Variable-Speed Gear, an hydraulic unit, have been made in units up to 200-hp. rating.

The JFS variable-speed transmission has been taken over to be distributed by Stephens-Adamson Manufacturing Co. This unit, which has been described in previous issues of INDUSTRIAL ENGINEER, is a mechanical device in which a special double-cone-shaped roller is shifted in a special race to give a variable speed. A planetary transmission may be built into the unit to give additional reduction.

Lubrication — Perhaps the most noticeable feature in connection with the solution of power transmission problems today is the greater attention that practically all industrial plants are giving to lubrication. Bearing performance is practically dependent on proper lubrication and continuous operation is dependent to a very large degree on bearing performance. The improvements in the methods of application of lubricants has advanced directly along with improvements in bearings. Each has helped to make the other possible.

Unless lubrication is handled properly a considerable percentage of the lubricant is wasted. Many industrial plants are finding that they can cooperate to advantage with the lubrication engineers of some of the oil companies specializing in this work in a study of the plant lubrication problem. Although much of the interest of users is aroused through the possibilities of making savings in the cost of lubricants, the savings resulting from decreased maintenance and continuous operation are usually much greater, although they cannot be so easily evaluated.

Considerable attention has been given within the past year or two to the use of automatic and force-feed lubrication. This includes the Alemite, Dot, and Zerk systems, some types of automatic-feed grease cups, and numerous other force-feed lubricating systems.

Two of the recently announced improvements are the Dot-O-Matic pressure grease cup and the application of centralized Dot lubrication, either from a hand gun or a power-driven gun, as is shown in the accompanying illustration on page 450. In this centralized system of lubrication small pipes extend from a central point which contains a battery of Dot fittings. The operator, while standing on the floor, can lubricate bearings on any part of the machine by applying the hand gun or the power gun to the fittings and forcing the lubricant through the pipes to the bearing.

On the press illustrated two men formerly spent about an hour each day climbing over the machine to lubricate the various bearings, some of which were almost inaccessible. During this time the machine necessarily remained idle. Since the installation of the new method of lubrication the operation of the machine is not interfered with and all bearings on the entire unit are lubricated in about 10 or 15 min. by one man. Each bearing receives individual attention.

The Dot-O-Matic automatic-feed grease cup resembles an improved compression grease cup provided with a Dot fitting for filling. The rate of discharge can be regulated to require from a day to a week. These cups are used on glass machines and other equipment that is in continuous operation and requires lubrication under severe service conditions.

The application of an Alemite fitting to a compression grease cup has been made by the Link-Belt Co. This development removes one of the most objectionable features of the grease cup in that it can now be filled without opening. Opening a grease cup to refill in dusty surroundings always exposes the lubricant.

These newer methods of application of grease to bearings are not in any respect similar to the old method of using grease. In the old-type, grease-lubricated bearing a heavy grease was generally used. In some cases the increased temperature of the bearing was depended on to melt the grease and distribute it. A grease of much lighter consistency is used in the automatic grease-feeding devices, in pressure guns, and other force-feed lubrication systems.

There has been considerable advancement recently in the use of oil circulating systems in connection with paper mill lubrication. This application is not entirely new but has passed through the development stage and now is becoming quite widely used. The oil passes through filtering and cooling equipment after leaving the bearings and is recirculated. Oil used in large gear cases in steel mills equipment is also frequently recirculated. These bearings use large quantities of oil, and because of its value and the danger of contamination if not properly cared for, greater attention is being given to oil storage and handling facilities.

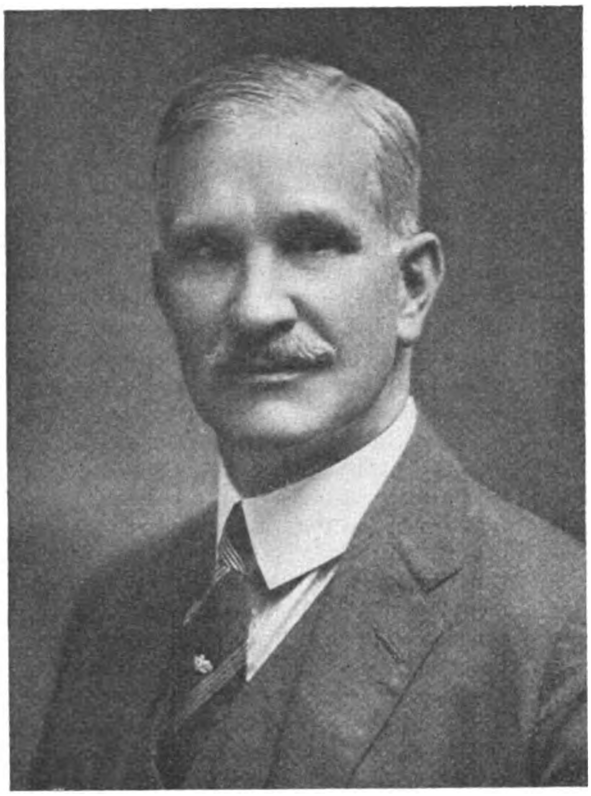
Every Power Drive Application Is an Individual Problem

By GEO. L. MARKLAND, JR.
Chairman of the Board, Philadelphia Gear Works, Philadelphia, Pa.

IN THE early days of our development as an industrial nation, power transmission problems did not play a very important part in plant operation. Industrial plants were comparatively few in number and small in size. Operating requirements and conditions were not very severe, as a rule, and efficiency of operation and reliability of service were not on the same plane they are today.

In these old plants one or more steam engines furnished all the motive power, which was transmitted from engines to lineshafts and from lineshafts to the machines almost entirely by leather belts. For the most part belts were well adapted to the demands placed on them.

As industrial plants became larger and were equipped with more complicated machinery, the problem of getting power from the engine to the machines became more troublesome. Then, too, the electric motor appeared on the scene and brought with it other problems that demanded attention. Essentially a high-speed machine, as compared with steam engines, provision had to be made for obtaining greater reductions in speed when a motor was used. As a result, other methods of connecting the source of power to the machine were needed, so that gears and, later on, chains, began to find wide application.



Geo. L. Markland, Jr.

As power transmission problems have become more complicated and the requirements more exacting, the manufacturers of power drive equipment have done a great deal of development and research work.

The tanning of leather is one of the oldest industries: yet within the past decade or so, many improvements have been made in the tanning and treatment of the leather used for making belts. A high-grade belt of today will render a quality of service that would have been impossible to obtain 25 or 30 years ago.

Twenty years ago gear drives were a nuisance, and regarded as a necessary evil. Usually they were extremely noisy in operation, and used valuable space.

Today the picture is entirely different. The metallurgist has given us special alloy steels and shown us how to heat-treat them to produce qualities and characteristics that were hardly dreamed of a few years ago. Old tooth-forms have been perfected, and new types of gearing developed. Radical changes have also been made in the methods and equipment used in cutting gears. These improvements have not only reduced unit costs, but have made it possible to cut gears to much closer limits than was formerly the case. The result is much quieter operation, reduction in the amount of power wasted through friction, and longer life of the drive elements.

Enclosing gear trains in an oil- and dust-tight case was a big step toward making gears serve more satisfactorily the needs of modern industry. Modern high-grade speed reducers are practically noiseless in operation, efficient, long-lived, require little attention, and present no injury hazard.

Chain drives have likewise been developed to a high state of perfection and are serving industry well. In fact, the same story could be told of every item of equipment that is used in the mechanical transmission of power.

As the result of all this development work, plant operating men today are faced with the problem of selecting the type of drive equipment that best meets the operating conditions and requirements in their plants. This is by no means always an easy task to accomplish satisfactorily.

There is no type of drive that is ideal for every application. All of the types of equipment that I have mentioned have won recognition because they have clearly demonstrated their value, when properly applied and taken care of intelligently. Each one possesses features that make it particularly adaptable to certain conditions.

In my estimation operating men cannot satisfactorily solve their power transmission problems on the basis of propaganda, hearsay, or personal opinion. These are essentially engineering problems and must be solved as such. This means that plant men must study their transmission problems individually with care, and make sure the requirements are not so severe that equipment will be called upon to do the impossible. Then, after thorough investigation of the methods and equipment available, they should select the type of drive that best meets all the conditions and will give the desired service with the greatest over-all economy and efficiency.

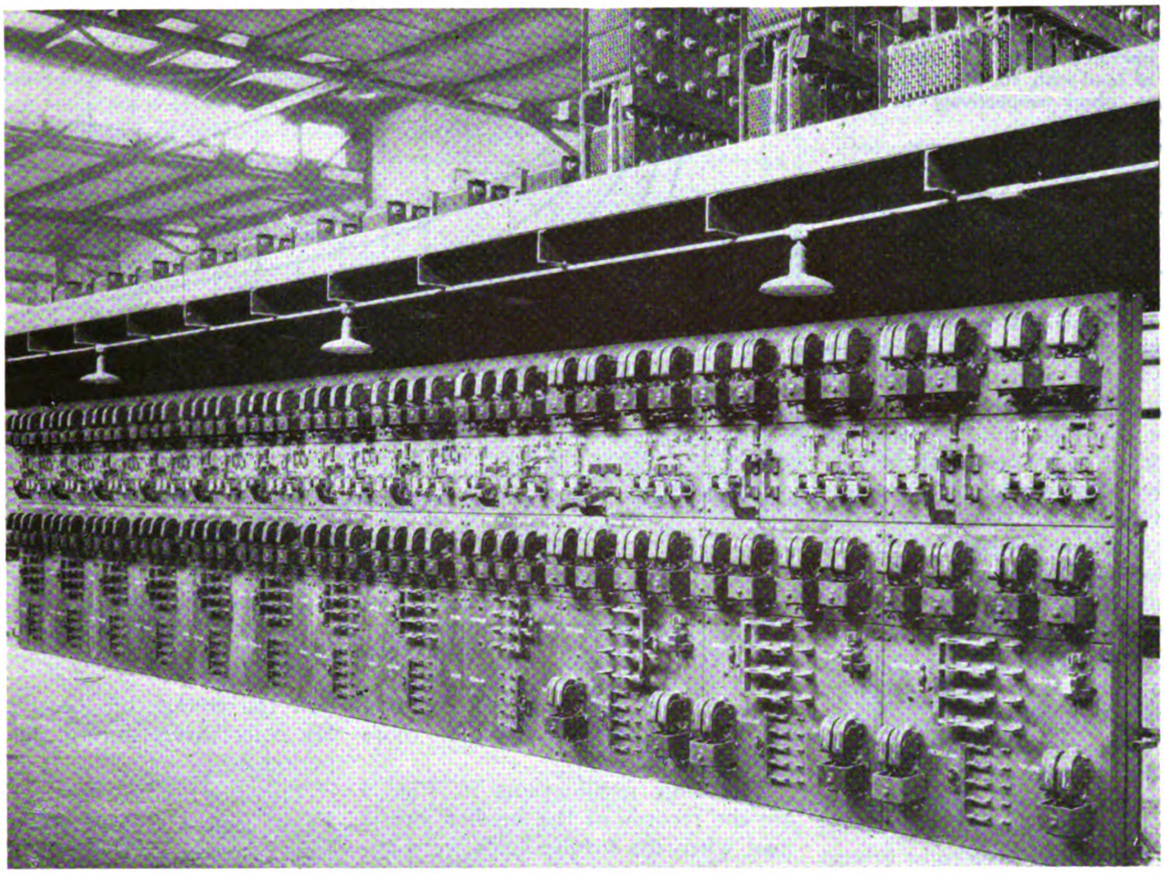


Fig. 1—These are the magnetic time control panels for the auxiliaries of a 28-in. structural finishing mill.

Time-Limit Control

of loads having large inertia

By B. W. JONES

Industrial Control Engineering Department, General Electric Co., Schenectady, N. Y.

IT IS quite generally recognized that time-limit control, like magnetic time direct-current control, gives good operating results when the motor drives loads like steel mill auxiliaries, crane hoists or similar loads where the inertia is not very great. Many questions, however, have been asked regarding the adaptability of time-limit control to loads which have a large inertia. This article will endeavor to analyze this subject and show what happens when the value of the inertia remains constant and the torque varies.

If both the inertia and the torque loads remain constant during the starting period, it is a simple matter to adjust each time relay so that the resultant current peaks will stay within the desired bounds. But, if the torque load varies the result is a little confusing. The relay setting given at the factory may not give the desired results and further adjustment on the job may become necessary. However, the factory setting can be made fairly close to the required value, and, therefore, the chances are good that little or no adjustment will have to be made in the field for the operating sequence.

The load condition that causes the most questioning is a fairly large inertia and also a widely-varying torque load. Let us assume that a series motor is driving the load and that the torque load will not materially exceed the full rated torque of the motor, but may range anywhere from rated torque down to zero. Also, assume that the time adjustments of the relays are such that the motor will accelerate the inertia load alone with one-half rated torque; that is, the relays provide sufficient time so that one-half rated torque of the motor will accelerate the inertia load. Now, if a half-rated torque load is added, the motor must develop rated torque during its accelerating period, in order to drive the inertia plus the half-torque load. Again, if a torque load equal to the rated torque of the motor is to be accelerated, the motor must develop one and one-half times rated torque in order to accelerate the inertia plus the torque load. From this simple analysis it is evident that any combination of inertia and torque loads can be handled without any complicated calculations.

The speed-torque curves of an MDS-106 motor are shown in Fig. 2 for a resistance having 30, 25, 20, and 15 per cent ohms in the several divisions. The left-hand group of steps shows the results when the

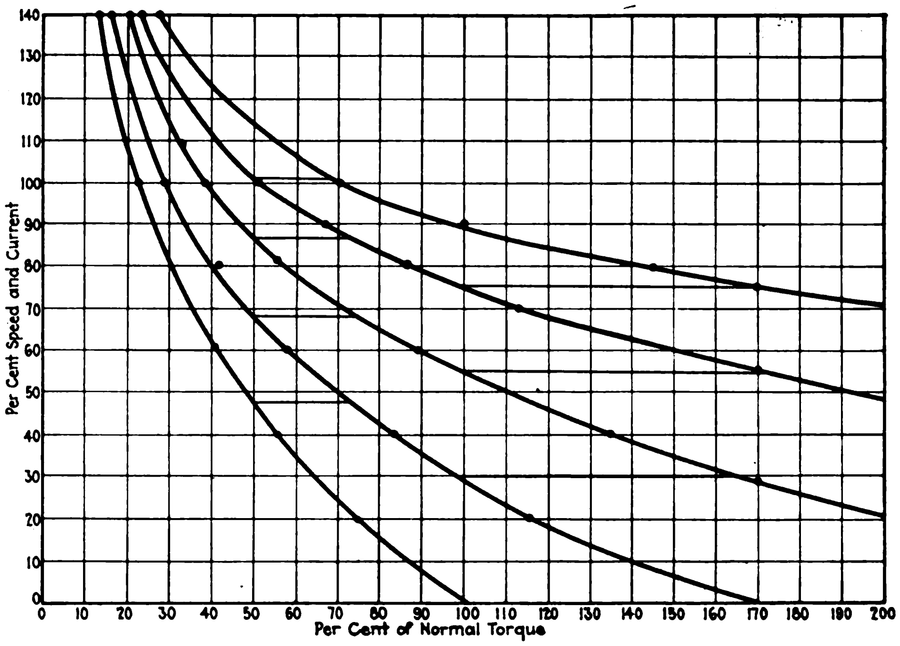


Fig. 2—Speed-torque curves of a series motor operated under different conditions of load with 30, 25, 20 and 15 per cent ohms respectively in the resistors.

The steps at the left represent the conditions when the inertia alone is accelerated. The right-hand group of steps shows the conditions when the inertia plus one-half rated torque is accelerated.

inertia alone is accelerated. The right-hand group of steps shows the results when the inertia plus one-half rated torque is accelerated. These steps are drawn on the basis that the several resistor divisions will be consecutively short-circuited when the current reduces to a 50 per cent value for the first or left-hand group of steps, and to 100 per cent value for the right-hand group.

However, the actual current value for the right-hand group will be somewhat less than these assumed values, which means that the maximum current peaks as shown in Fig. 2, are a little higher than they would be in practice. This is true because the resultant torque jumps between the left and the right groups of steps are more than 50 per cent, which are intended to take care of the 50 per cent added torque loads, and because the maximum speed at the higher load is lower than at the light loads.

A test was recently run to check the accuracy of the above assumptions. Oscillograph records were made of the current, the counter-e.m.f., and the time. For this purpose a series motor was geared to two inertia loads, one being 1.3 times the WR^2 of the armature, and the other one 20 times the WR^2 of the armature. The first case represents a very common value of inertia found in most loads, whereas the second case represents a very large amount of inertia, which is found in only a few loads. The torque loads were obtained by a friction brake. This was adjusted to represent various loads from practically zero to more than twice normal.

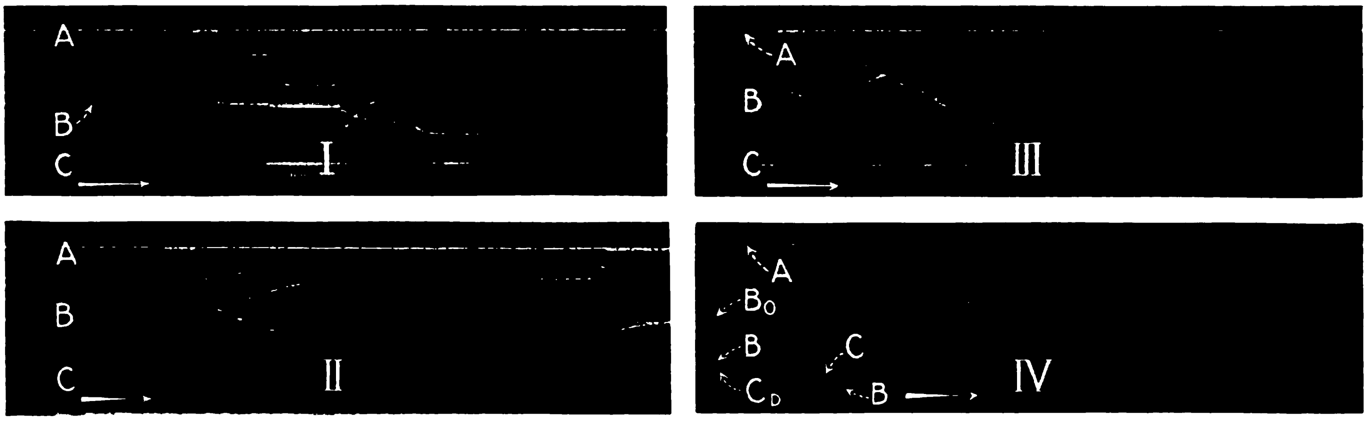
The four oscillograms in Fig. 3 are the records of the smaller inertia load when the torque loads were adjusted respectively for 200, 100, 33, and 33 per cent of normal. In these oscillograms curve *A* represents the armature current, and curve *B* the armature voltage. In Figs. 3, I, II, and III, curve *C* is the 40-cycle timing wave. In Fig. 3 IV, curve *C* shows how the voltage on the plugging relay coils varies during the plugging period.

The four oscillograms I, II, III and IV in Fig. 4 are the records of the larger inertia loads where the torque loads were adjusted respectively for 33, 100, 200, and 33 per cent of normal. The oscillograms in Figs. 4 I, II, and III have a 40-cycle timing wave; in Fig. 4 IV the timing wave is replaced by a voltage curve, which shows how the voltage on the plugging relay coil varies during the plugging period. In these oscillograms also, curve *A* represents the armature current, and curve *B* the armature voltage. The result of an analysis of these oscillograms, in Figs. 3 and 4, showing the currents, volts, and time in seconds between closing of contactors is given in the accompanying table.

It will be seen that the voltages impressed on the coil of the plug relay at the instant when the line contactor closes (when the motor is plugged) and when the plug relay

Fig. 3—These oscillograms show the conditions when operating a series motor under a small inertia load and various values of torque load.

The inertia load was 1.3 times the WR^2 of the armature. Oscillogram *I* represents a reversing test with a torque load of 200 per cent of normal; *II*, with a load 100 per cent of normal; *III*, with a load 33 per cent of normal; *IV*, an acceleration test with a load 33 per cent of normal. In these oscillograms curve *A* represents the zero line of the armature current and *II* the armature voltage. In oscillogram *IV* the 40-cycle timing wave has been replaced with a voltage curve which shows the voltage variation across the plugging relay coils during the plugging period. These oscillograms, as well as those in Fig. 4, are analyzed in the table given in the text.



Analysis of Oscillograph Records Shown in Figs. 3 and 4

Time in seconds between closing of contactors

Torque Load Per Cent	Light Inertia Load			Heavy Inertia Load		
	Line and Plug Contactors	Plug and 1A Contactors	1A and 2A Contactors	Line and Plug Contactors	Plug and 1A Contactors	1A and 2A Contactors
33	.87	.52	.48	5.3	1.88	....
100	.37	.52	.48	2.65	1.87	1.5
200	.30	.52	.52	1.4	2.00	1.55

Current values just before and after closing of contactors

Torque Load Per Cent	Light Inertia Load				Heavy Inertia Load			
	Line Contactor	Plug Contactor	1A Contactor	2A Contactor	Line Contactor	Plug Contactor	1A Contactor	2A Contactor
33	0/340	170/350	148/222	117/138	0/258	140/320	206/350	....
100	0/160	127/255	180/286	170/244	0/216	144/310	227/410	250/420
200	0/122	122/265	265/470	308/490	0/185	135/290	260/485	340/620

picks up to let the plug contactor close, are:

Minus 24 volts when the line contactor closes.

Plus 133 volts when the plug relay closes.

It is evident from these results that time control is applicable to light and heavy inertia loads where the torque loads vary over wide limits.

Fig. 5 represents the graphic ammeter record of the current input to a 70-hp., 220-volt series motor with magnetic time control. This motor drives a rail-mill table approximately 75 ft. long, consisting of 20 rollers. Extremely rapid operation is not essential to maintain the desired production and the timing of the relays has been adjusted to give a rather long delay. The interval between the closing of the forward or reverse contactors and the closing of the last accelerating contactor is approximately 1.8 sec. when the motor is started from rest. When the motor is plugged the interval is about 3.75 sec.

With the type of control previously used with this motor the current peaks were between 700 and 800 amp. Since the installation of the present controller the current peaks have been reduced to a maximum of about 350 amp., as will be seen from Fig. 5.

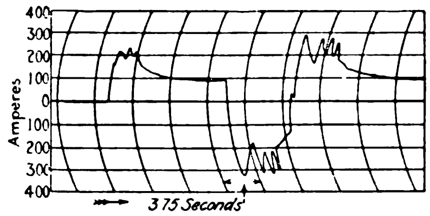


Fig. 5—This graphic ammeter record shows the current drawn by a 70-hp. reversing series mill motor controlled by a magnetic time controller.

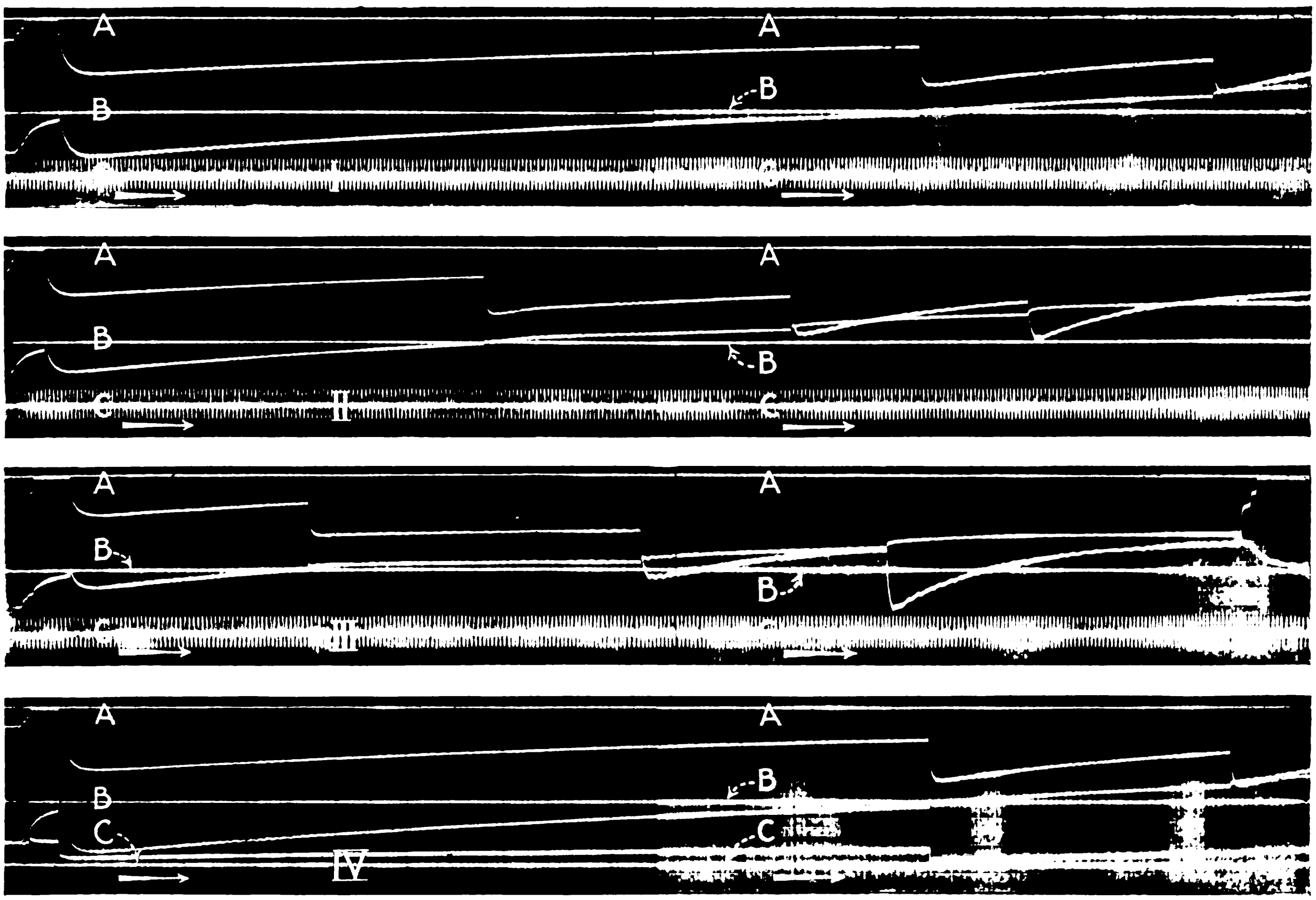


Fig. 4—In this case the motor was reversed under a heavy inertia load and different values of torque load.

The inertia load was 20 times the WR^2 of the armature. Oscillogram *I* shows the conditions when the motor was reversed under a torque load 33 per cent of normal; *II*, under a load 100 per cent of normal; *III*, under a load 200 per cent of normal, and *IV*, under the same load with the 40-cycle timing wave replaced by a voltage curve showing the voltage across the plugging relay coils during plugging. As in the case of Fig. 3, curve *A* in the oscillograms represents the zero line of the armature current and curve *B* the armature voltage.

What has been said heretofore applies to the acceleration of the motor. Inasmuch as the motor may be started from rest, or may be plugged from a high speed in the opposite direction, the plugging contactor should be controlled by some current-limiting means. In the General Electric magnetic time type of control, the principle of having the counter-e.m.f. of the motor buck the IR drops of the plugging section of the resistor, is used. This causes the plugging contactor to close instantly if the motor is at rest, but if the motor is running in the opposite direction, it must come substantially to rest before the plugging or any of the accelerating contactors can close.

It may, therefore, be assumed that control working on the function of time can be applied to loads that have a widely-varying torque value such as a crane hoist, or to an inertia load such as the trolley motion on a man trolley ore bridge, or to an inertia load which has, in addition, a varying torque load, such as a low-pressure fan which may have the discharge either open or closed. It should not, however, be applied to a load whose inertia is of large magnitude as compared with its torque load, and varies to a considerable degree. Such a load is, however, very uncommon.

The principal limitation in applying time-functioned control for direct-current motors has not been its misapplication to the varied types of loads, but has been the lack of a suitable relay for producing a sufficient time delay for some loads. An impetus towards the use of time-delay control has been given by the design of the magnetic time control mentioned, which uses an induction time-delay relay. The controlling relays on these panels are simple, and dependable, which are the requirements for success. However, they have one limitation: the maximum time for which they can be adjusted is approximately 1 sec., and there are some applications where more than 1 sec. per relay is required.

Recently, a new relay has been developed that can be mechanically connected to direct-current contactors rated at 150 to 600 amp., inclusive, or to alternating-current contactors rated at 75 amp. and above. It can be adjusted over a range of 0.5 to 8 sec. Therefore, by means of the induction time-delay relay for direct-current control and the new relay for either alternating- or direct-current control, the principle of time delay for governing the acceleration of motors can be used for the majority of control applications.

Using Two Idlers to Increase Arc of Contact

In a large plant that was rapidly expanding, it was found necessary to increase the load on the engine from about 170 hp. to 275 hp. Space limitations prevented a change in the respective positions of the driving and driven pulleys unless very expensive alterations were made. Consequently, it was decided to devise some method of increasing the horsepower transmitted, without making any radical changes in the layout.

Triple-ply leather belts 20 in. wide had previously been used on this drive with unsatisfactory results, when the load was increased. These belts had stood up only from four to nine months, running at a speed of a little more than 2,600 f.p.m.

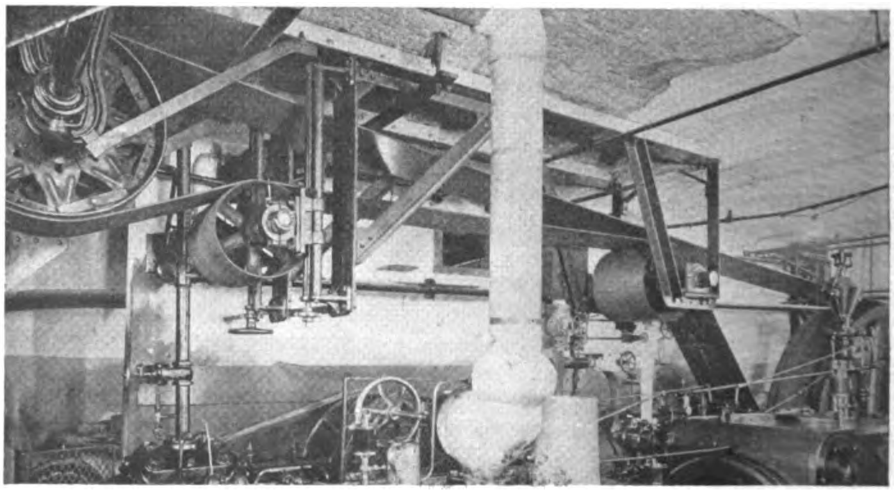
The pulleys are of fair size and in order to increase the arc of contact on the pulleys and also raise the lower strand of the belt over some other equipment that was in the way, two idler or carrier pulleys were installed. One of these idlers is adjustable so that the belt tension can be regulated.

In view of the severity of the service to which the belt was subjected a 20-in. Gripotan belt with a Tannate ply on the side next to the pulleys was installed. This belt has now been in use for more than five years, carrying the maximum load of 275 hp. without apparent difficulty or need of much maintenance attention.

J. Edgar Rhoads.

J. E. Rhoads & Sons,
Philadelphia, Pa.

Use of a special belt and two idlers made it possible to increase considerably the load on this drive.



Abuse of Belt Drives on High-Inertia Loads

Where belts are used to transmit power from a motor to the driven machine it frequently happens that the most severe strain on the belt occurs when the motor is started. This is particularly true when the driven equipment has high inertia.

Present practice is to drive flywheel loads with a motor whose rating corresponds as closely as possible to the actual load. This necessitates the use of a high-resistance rotor, in order to obtain the required starting torque. If such a motor is started on too high voltage the torque produced may cause severe slipping and straining of the belt.

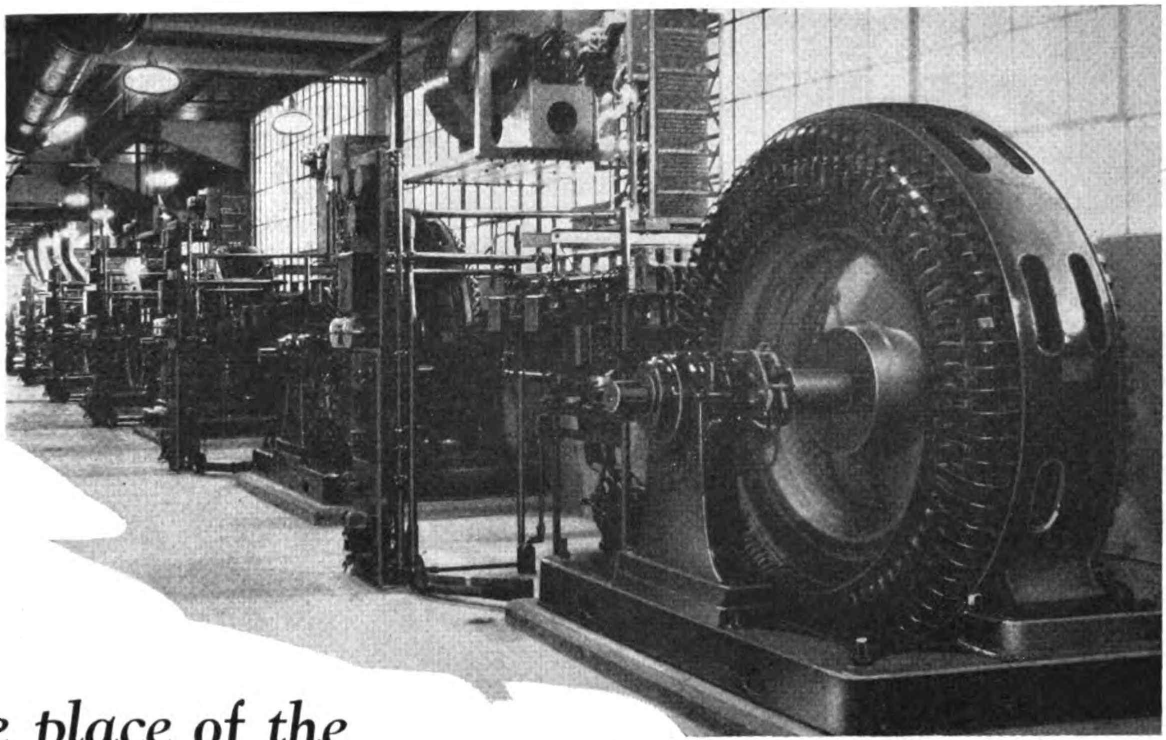
An instance of this sort came up in a large eastern plant. Here the motors driving the heavy abrasive wheels on a number of swinging grinders were being started on such high voltage that they came up to speed too rapidly. In consequence the belts were short-lived and gave a great deal of trouble.

The frictional heat generated by the belts slipping on the pulleys would char the inside of the belt in spots. There was also a tendency for the belts to narrow down and the surface developed deep cracks, clearly showing the strain to which they had been subjected.

The obvious remedy was to start the motors on a lower voltage than could be obtained with the starting equipment than in use. Accordingly, our primary-resistance starters were installed. These starters make it possible for the operators to bring the motors gradually up to speed, so that the grinding wheels have more time to accelerate and belt troubles have been eliminated.

W. B. Neeper.

Engineering Dept.,
Allen-Bradley Co.,
Milwaukee, Wis.


1,000-hp., low-speed synchronous motors driving pulp grinders.

The place of the Synchronous Motor *in industry*

By C. D. KESTER
Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

ADVANTAGES resulting from the use of synchronous motors have not until recent years been fully appreciated. Before the war the price of generating and other power plant equipment was such that little attention was given to power factor and the means by which it could be improved.

During this period the principal synchronous motor applications were on the low-speed compressors, the larger centrifugal pumping installations and, of course, motor-generator sets. Inasmuch as the compressors operate at low speed, the synchronous motor represented a lower first cost than induction motors and provided better performance. The pumping installation represented in most cases a steady, continuous load, where higher cost for high-speed synchronous motors could be justified by their higher efficiency.

Large motor-generator sets were usually operated continuously, and in a number of cases power factor correction was supplied by applying the proper synchronous motor. Here again high efficiency was important, even if no power factor correction were desired.

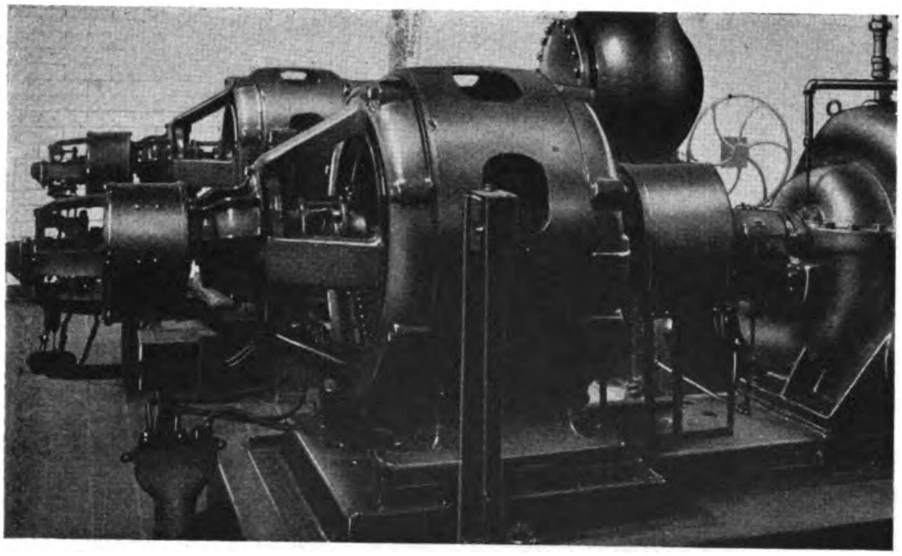
As late as 1919 the total demand for synchronous motors was only a small percentage of the present-day demand, and until that time had been too small to induce manufacturers generally to design synchronous motors with the most advantageous characteristics. The existent demand was in general supplied by motors made from existing alternating-current generator parts. This often necessitated sacrificing some important motor characteristics. Also, in former days the starting equipment was somewhat cumbersome and required fairly skilled operators.

As soon as we settled down to real business after the war, something happened. The price of power plant equipment had soared so high that the derating effect of low power factor on generating equipment was studied in earnest. Large power companies found that raising the power factor of their load from 65 per cent to 85 per cent was equivalent to installing an additional 20,000-kva. turbo-generator.

Following up this situation logically and patiently on the part of central stations and other large power producers gave synchronous motor demand an immense impetus. As the demand grew, motor manufacturers gave more and more attention to the design of synchronous motors and starting equipment for them.

The user of synchronous motors was already enjoying lower power bills due to better performance of these machines, but now he began to benefit by the better power rate based on his high power factor. This growing appreciation of benefits of high power factor, together with the development of simple and dependable starting equipment, has brought about the rapidly increasing demand for synchronous motors.

The power factor of every plant using alternating-current equipment should be given careful consideration. The lagging power factor caused by induction apparatus such as transformers, induction motors, electric



High-speed synchronous motors are well adapted for driving centrifugal pumps.
The two motors shown here are of 300-hp. rating and have direct-connected exciters.

furnaces, and so on, is brought about by the magnetizing current drawn from the line. Low power factor means larger generating, transmission and transforming equipment in order to provide the necessary useful or load current. The voltage regulation is also likely to be poor.

The purchaser of power is penalized by low power factor in his plant by the increased size of cables, switching, and other equipment, to say nothing of the voltage regulation, which affects the speed of loaded induction motors.

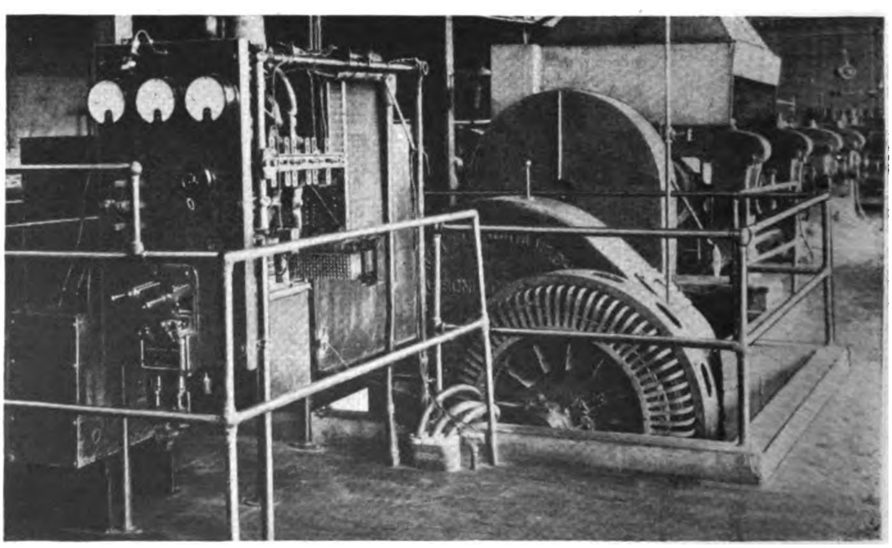
Whereas the magnetizing current is supplied to induction equipment from the power line, the synchronous motor supplies its own magnetizing current through direct-current excitation and is, therefore, capable of operating at a predetermined power factor—unity or some per cent leading for corrective purposes—depending upon the amount of excitation. Where suitable synchronous motor applications are available, power factor correction by this method is practically always the most economical. With a drive to be electrified the additional cost of a synchronous motor large enough to give power factor correction over the cost of one just large enough to carry the load is very small—practically always negligible when the benefits of high power factor are capitalized. Power factor correction has spread to such a point that there are now available high-speed, general-purpose synchronous motors in ratings of 200 hp. and down to 50 hp. and below for various applications. The high-speed motors above 200 hp. rating are known as large synchronous motors.

The modern synchronous motor is so designed that its electrical characteristics can be modified easily to meet the requirements of the majority of present-day industrial drives with the exception of those utilizing flywheel effect to advantage. Of course, flywheel effect is used in connection with synchronous motors driving compressors for smoothing out the impulses imposed by the compressor, but where the application uses a flywheel for carrying the peak loads, such as is experienced in certain types of steel rolling mills where there is a peak lasting for several seconds, the synchronous motor is not applicable. It is inherently a constant-speed machine. Hence we may say in general that synchronous motors are applicable to any constant-speed drive where flywheel effect, as here-before explained, is of no advantage.

In simplicity of construction the synchronous motor is about on a par with a squirrel-cage induction motor, but it is simpler than the wound rotor motor; hence it can be said that it is at least as simple as if not simpler than induction motors as a whole and utilizes a larger air gap, which is a decided advantage. The synchronous motor requires additional equipment in the form of a source of excitation, either a separate exciter or excitation from a bus, but the exciter is a very simple and standard piece of equipment from which little or no trouble may be expected. Where one or more synchronous motors are installed in one location it is often feasible to excite them from a common bus, thus simplifying the excitation equipment.

In order to vary the excitation and thus the power factor at which the motor operates it is necessary to provide a rheostat. In most cases of individual exciter installations the small exciter rheostat only is required, whereas in some instances a main motor field rheostat is used. However, when starting up the majority of installations, the rheostat is set and forgotten. The simplicity and reliability of the rheostat are matters of common knowledge. The corrective effect of the synchronous motor increases as the load decreases, provided the normal excitation is allowed to remain constant.

These motors are built standard to operate at 100 per cent and 80 per cent leading power factor, and these two power factor classifications cover by far the majority of applications. The 100 per cent power factor machine is applied where very little corrective effect is necessary, or where it is desired to maintain practically the



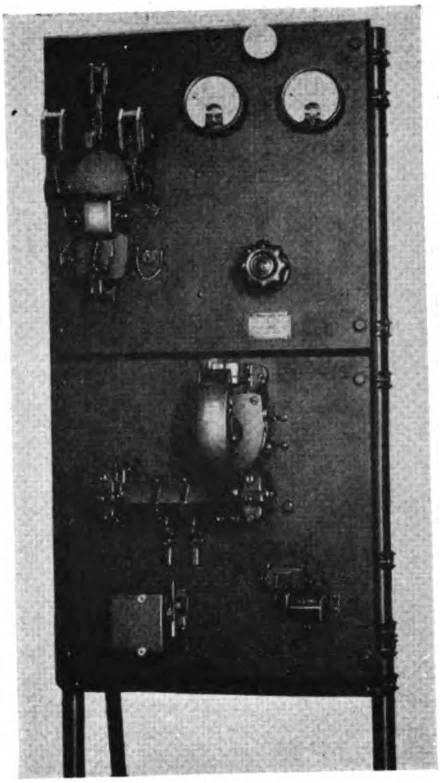
This 350-hp. high-speed synchronous motor drives a rubber mill line through a speed reduction unit.

same power factor, whereas the 80 per cent leading power factor motor is used where corrective effect is required. Occasionally a motor of greater leading power factor, such as 70 per cent, is required and can, of course, be furnished on special order.

Synchronous motors are divided into two general classes according to speed: high speed, which includes those operating at 450 r.p.m. and above; and low speed motors operating at 400 r.p.m. and below. In appearance these motors differ essentially in width and rotor construction. The high-speed motors are comparatively wide, with laminated rotors and dovetailed poles, whereas the low-speed motors are comparatively narrow, having a rotor with bolted-on field poles.

High-speed motors are built in sizes below 50 hp., but it is difficult to justify the use of sizes very much below this because of the considerably higher prices, compared with those of induction motors and the relatively small amount of power factor correction possible. Above 50 hp. rating the inherent advantages of the synchronous motor must not be neglected. Also, the price difference between synchronous and induction motors is diminishing, as will be mentioned later.

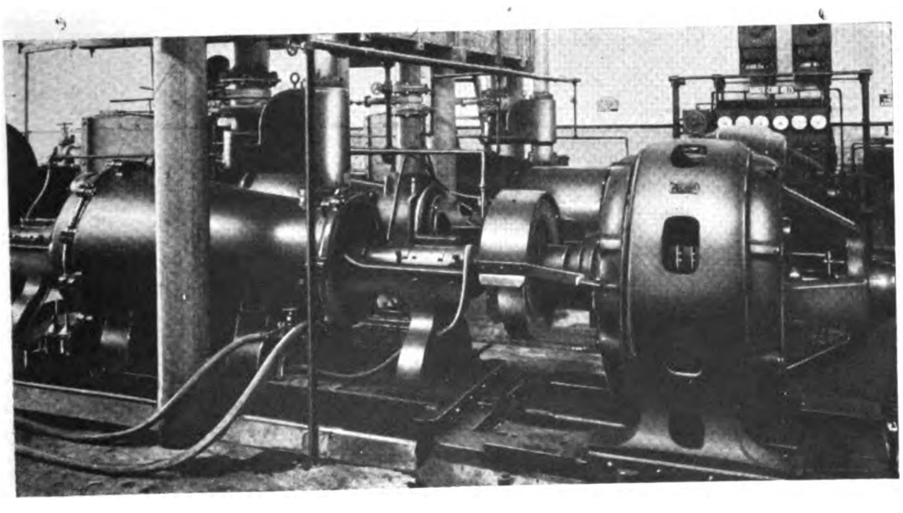
Starting equipment for high-speed synchronous motors is very simple; the application of field excitation is done at the right time automatically. The starting operations are the same as for the squirrel-cage induction motor. Many high-speed motors below 1,800 r.p.m. can be thrown across the line without objectionable inrush of current, further simplifying the control. The current inrush is in general inversely proportional to the number of poles—the smaller the number of poles the higher the inrush on full-voltage starting.



Control equipment for synchronous motors has been greatly simplified during the past few years.

This illustration shows a 2,200-volt fully automatic, across-the-line starter for a synchronous motor. All low-speed motors can be started on full voltage without objectionable current inrush. It is frequently desirable, however, to start high-speed motors on reduced voltage.

There is a sub-classification under high-speed motors to include high-efficiency centrifugal pump motors with ratings of 200 hp. and above at 1,200 r.p.m., and 100 hp. and above at 1,800 r.p.m. Most municipalities are insistent on high efficiency, and various industries are becoming more favorable to this class of motor for driving centrifugal pumps, especially those that are operating continuously under a reasonably steady load. The saving on such drives due to high efficiency is considerable. These motors cost quite a little more than the general-purpose and large, high-speed synchronous motors, but the high efficiency soon writes off this difference. For pumps requiring motors rated below the horsepower range heretofore given, general-purpose synchronous motors should be used down to, in general, 50 hp., and induction motors below this.



In this paper mill the jordans are driven by 400-hp., low-speed synchronous motors connected directly to the shaft.

High-speed synchronous motors are now extensively used for such applications as,

Belted to general lineshaft drives.
Belted to or coupled to centrifugal pumps.
Belted or coupled to fans and blowers.
Belted or geared through jackshafts to gyratory crushers.
Geared to reciprocating pumps.
Geared to rubber mill lines.
Geared to metal-rolling mills.
Belted to compressors.
Motor-generator sets.

Low-speed motors are also built in sizes below 50 hp., but the statements made in regard to high-speed motors apply, in general, here. Very good use can be made of a high-starting-torque, belted squirrel-cage motor for many cases where the demand comes much below 50 hp.

The starting equipment for low-speed synchronous motors is also very simple, with the field excitation automatically applied. All low-speed motors can be started on full voltage and the full-automatic, push-button-operated, across-the-line starting equipment is the most popular for these machines. Either hand- or magnetically-operated reduced voltage control can be used where desired if the starting torque on reduced voltage is sufficient for the particular application.

Low-speed synchronous motors are widely used as engine type for driving compressors and for such coupled applications as,

Sewage pumps.
Rubber mill lineshafts.
Pulp grinders and jordans.
Steel-rolling mills.
Band saw mills.
Ball, tube and rod mills.
Large slow-speed fans, blowers.

There are several high-torque applications for both high- and low-speed synchronous motors which require individual attention by the manufacturer of this type of equipment.

There is a second stage to the im-

petus behind this synchronous motor demand. The larger production than in former days results in economies that are reflected in the prices. In general the synchronous motor with direct-connected exciter costs only slightly more than the corresponding squirrel-cage induction motor in the smaller, high-speed sizes. This difference is greatest in the very small sizes and decreases as the size approaches 200 hp., rating, above which the price differential will usually be in favor of the synchronous motor. There are two exceptions to this—the high-speed pump motors previously mentioned, and the two-pole turbo type, which does not begin to compete with the squirrel-cage motor until a rating of 500 or 600 hp. is reached. The cost of the low-speed motor with belted exciter is pretty generally as favorable as that of either type of induction motor, and sometimes more favorable. Being built for speeds of 400 r.p.m. and down, the construction is simpler and less expensive.

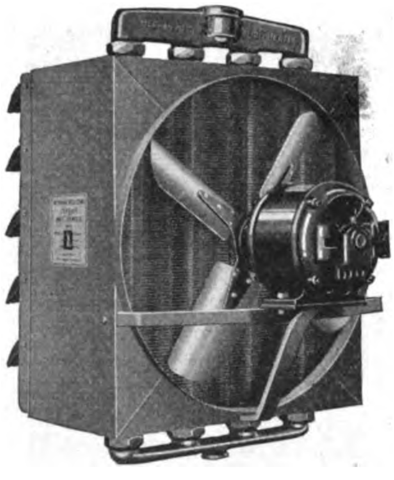
The ever-widening field of synchronous motor applications has brought about many improvements in design which are of direct benefit to the user. One of the latest designs is a low-speed, engine-type synchronous motor of welded structural steel construction. Directed ventilation is employed, giving even temperature rise with no hot spots.

The synchronous motor, together with simple and reliable control, is keeping pace with the demand and promises to eliminate much of the power factor waste that is still cutting into profits. It also promises to provide a more economical method of converting electrical into mechanical energy.

Correction in "Application of Unit Heaters in Industrial Plants"

DUE to a typographical error the photograph in the upper left-hand corner of page 353 of the August issue, in the article entitled "Application of Unit Heaters in Industrial Plants," was credited to another manufacturer when it should have been credited to The Herman Nelson Corporation, Moline, Ill. A later model of this Herman Nelson hiJet unit heater is shown here.

This unit heater is a special, extended surface, high-radiating capacity unit. The steam section or core of the radiator is wedge-shaped with aluminum fins extending at right



Herman Nelson unit heater

angles. These fins are firmly wedged in parallel and keyed in position. The core is cast in one piece and, it is stated, that the wedging and keying of the fins on the core give a close, metal-to-metal contact which does not loosen.

Trouble with Calender Drive Traced to Eccentric Gear

IN a Chicago industrial plant, one of the hardest drives, at least from the standpoint of the amount of trouble caused, was on a calender roll.

The calender roll giving trouble was gear-driven from a motor whose pinion seldom averaged more than three months' service. Pinions of various materials were tried without much improvement or lessening of noise. It was evident that something was radically wrong with the installation, or the load was too great.

A careful check-up of the drive disclosed the fact that the large bull-gear had been bored slightly off center, but true. At slow speed the irregular motion was not obvious to the eye nor easily detected but a careful measurement indicated the high and low sides of the gear. This difference was greater than the clearance allowance and caused the teeth to bind during part of the rotation and operate with excess backlash when the other half of the gear went into mesh with the pinion.

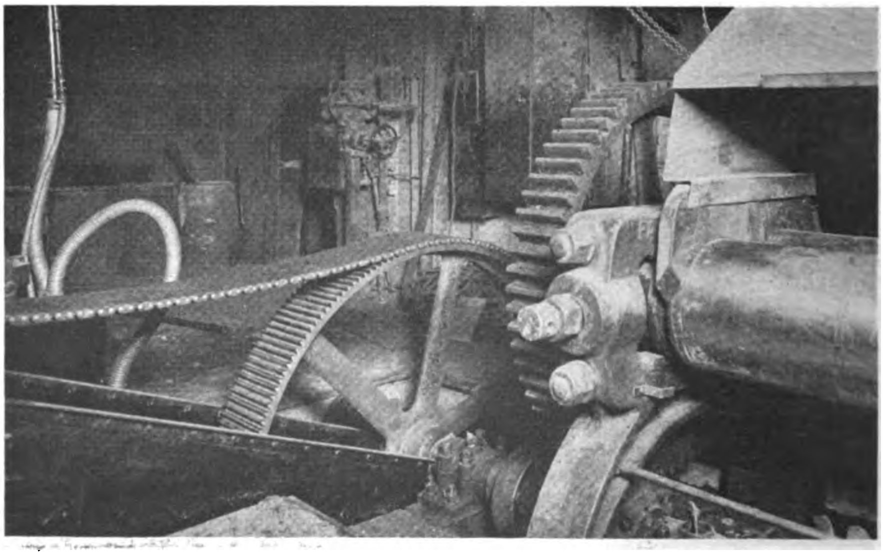
After locating the cause of the trouble, it was decided to change the drive entirely, instead of getting a new bull-gear. To give greater flexibility between the motor and the machine than is possible with a gear and pinion, but at the same time retain the positive feature of the gear drive, a chain drive was installed, similar to the calender drive shown in the accompanying illustration. The first drive was rated 45 hp. and an American High Speed chain was used.

This installation operated so satisfactorily that the drive illustrated was installed later on. This drive is of 100-hp. rating and connects the motor to a jackshaft built into and driving two calenders through gears. Only one of the calenders is shown in the illustration.

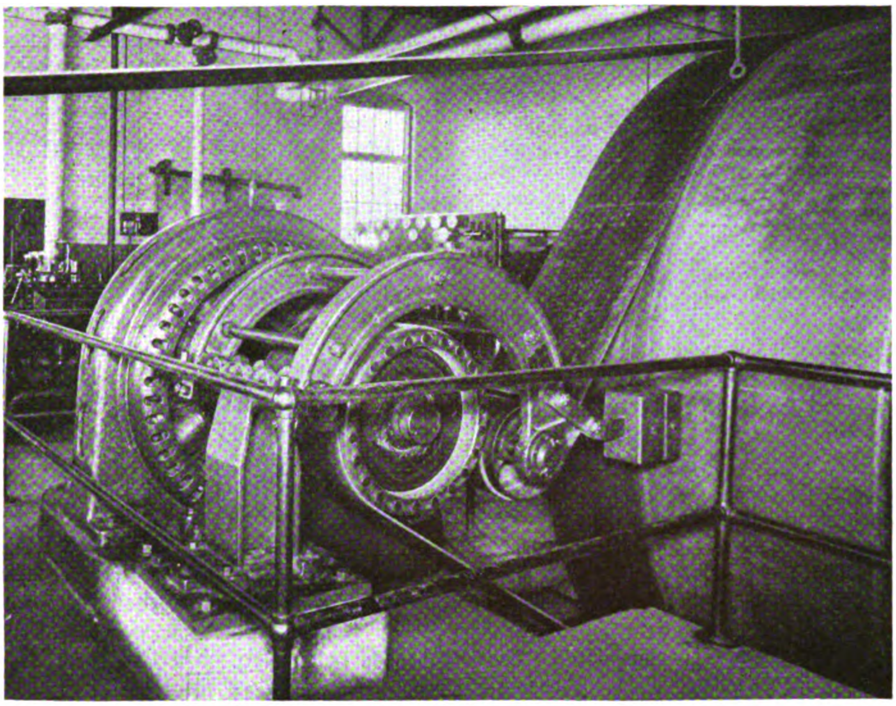
The jackshaft is driven at 55.8 r.p.m. from the 100-hp., 550-r.p.m. motor by a 12-in., 1½-in. pitch American High Speed chain running on 85.62-in. centers. A 19-tooth, case-hardened steel pinion is used on the motor and a 187-tooth, cast-iron sprocket on the shaft.

Chain drive on a jackshaft geared to two calenders.

The chain is used to absorb the shock and vibration and still maintain the advantages of a fixed ratio and positive reduction that would be given by a direct gear connection between the motor pinion and the large gear on this jackshaft. This chain sprocket is mounted on pillow-blocks and connected to the jackshaft by a flexible coupling.



Crowded conditions in an engine room required that this drive be employed to connect a new generator to the



main engine. The belt that drives a countershaft at the left is mounted on top of the belt driving the generator.

Transmitting power through

Short-Center Drives

IN LAYING out a new installation, or revamping an old one, conditions frequently make it necessary to transmit power from one shaft to another when the distance between the centers of the shafts is unusually short and a change in speed is required. Sometimes the desire or necessity of conserving floor space demands the use of a very compact drive. In other cases obstructions in the way of building columns, other equipment, and so on, render it necessary to mount the driving and driven shafts close together. In any event, a problem in power transmission is presented that is often troublesome.

When belt drives are operated on short centers over pulleys that are of widely different diameters the arc of contact on the motor pulley may be small enough to produce very unsatisfactory operation. If uncorrected, a small arc of contact leads to excessive belt slippage, which in turn causes loss of power and speed and induces rapid belt wear. Sometimes an attempt is made to reduce slippage by running the belt under extra-heavy tension. This expedient may be more or less successful in reducing slippage, but it inevitably leads to short belt life and abnormal bearing friction and wear.

Without going into a detailed discussion of this problem and the methods of solving it, it may be said that belts of special tannage or treatment that increases the coefficient of friction, as well as various types of gravity idlers that increase the arc of contact have been successfully employed in overcoming the troubles encountered with short-center belt drives.

On the other hand, the installation of a chain drive or direct connection through a speed reducer will oftentimes prove to be the solution of short-center drive problems.

Intelligent selection of the equipment for a short center drive must be based on a careful study of the operating requirements and conditions. The best type of drive for one installation may not be equally well adapted to another one in which the conditions are different. Basically, the problem is not one of picking out a drive arrangement that is merely workable. As in the case of all power drive applications, the ideal to be aimed at is the installation of a drive that will best meet the requirements from the standpoint of giving the desired results with the greatest efficiency and reliability, and at the lowest cost for maintenance attention. This can be accomplished with certainty only when a thorough understanding of the operating requirements and a sound knowledge of the advantages and limitations of the various types of drives available are brought to bear on the problem.

Details of a few installations will be given below to show how short-center drive problems have been solved in a number of industrial plants.

R. SALMONSEN, *Mechanical Engineer, F. L. Smidth Co., New York, N. Y.*—When the problem of installing a generator unit in a plant already taxed for space was settled, a Lenix drive was selected for the in-

stallation in connection with a tandem-belt drive, as shown in the illustration on page 461. A drive of this type was used because the full width of the 52-in. face engine flywheel was already being utilized by belts, one being a 30-in. main lineshaft belt, shown in the right-hand corner of the illustration, and one 16-in. countershaft belt, shown toward the left side of the illustration. With this arrangement, the engine could be loaded to only about two-thirds of its rated capacity.

To utilize the full capacity of the engine, the layout required that the new 20-in. wide, 150-kva. alternator belt be driven from the main engine pulley, and underneath the existing 16-in. countershaft belt.

The belt stretch on the generator drive is automatically taken care of by the Lenix drive, a constant belt tension being maintained at all times. The large arc of belt contact and the compactness of the arrangement were particularly desirable as ample passageway, it will be noticed, is still provided. Incidentally, the efficiency of the countershaft drive was improved due to the higher coefficient of friction resulting from the leather countershaft belt riding directly on top of the leather generator belt.

H. F. WEBER, *Engineer, Link-Belt Company, Chicago, Ill.*—At the plant of the Illinois Wire and Cable Co., Sycamore, Ill., it was necessary to transmit power from a motor running at 695 r.p.m. to a draw bench whose speed of operation approximated 195 r.p.m. The difficulties encountered on this 150-hp. drive were the necessity for a large speed reduction and a short-center drive of 38 in. because there was no more room available between the motor and the driving shaft of the machine.

It was obvious that the drive equipment used in this installation would be subjected to the severest kind of service on account of the size of the drive, amount of power to be transmitted, and the short center distance between the shafts.

After a careful analysis of the problem we decided to apply a 17-tooth driving pinion on the motor and a 68-tooth driven gear on the bench, with a 1½-in. pitch, silent chain 12 in. wide as the drive connection. The drive was installed in 1922 and is still giving good service.

K. D. HAMILTON, *Mechanical Department, Geo. E. Keith Co., Campello, Brockton, Mass.* — An interesting problem came up at our plant in connection with the drive for a large, slow-speed planing mill exhauster. The trouble that we had was caused by the extremely short center distance between the driving and driven pulleys.

First of all a chain drive operated from an 850-r.p.m., 100-hp. motor was selected for the job of driving the planer. This drive operated satisfactorily for only a comparatively short time. Evidently the very short centers and the peculiar conditions under which the exhaust fan was installed caused vibration to be set up in the chain and caused excessive heating of the motor bearings.

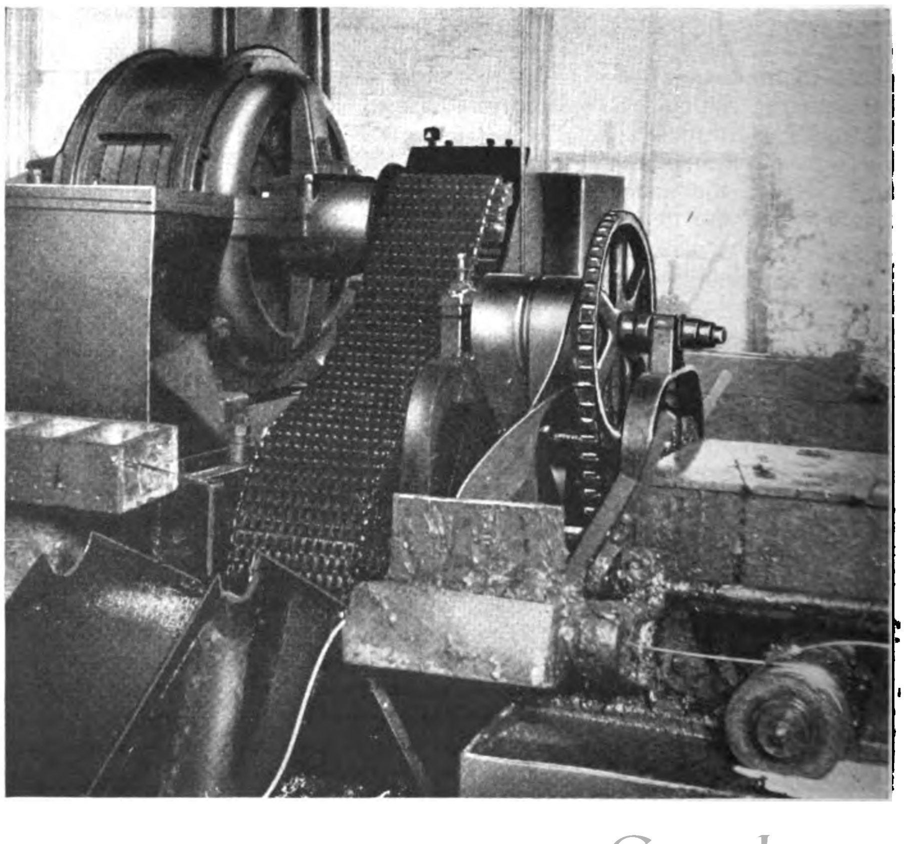
After considerable experimenting, it was finally decided to remove the chain and install a double belt 18-in. wide, although the pulley centers were only 6 ft. apart. This belt drive also proved to be unsatisfactory, for when the exhaust fan operated at full load, we experienced excessive slipping of the belt on the motor pulley, due to the small arc of contact. To overcome this difficulty an idler pulley was installed near the motor end of the drive.

This idler sufficiently increased the arc of contact on the motor pulley to prevent any slipping of the belt even when the motor was loaded to capacity. After the belt slipping trouble had been eliminated, all vibration of the motor disappeared and the motor bearings operated at their normal running temperature.

J. A. MARLAND, *W. A. Jones Foundry & Machine Co., Chicago, Ill.*—The management of a large steel fabricating plant recently decided to increase the productive capacity in one department by the addition of a machine in which one operation requires a very slow motion. This installation presented several interesting problems. One of these was the requirement that the drive be as compact as possible, as floor space was at a premium. The reduction ratio was 120:1 and it was necessary to drive two parallel shafts on the machine at low speed.

Other machines of the same kind that were installed several years ago are driven by a motor through two high-speed chains. The motors are mounted on sliderails and drive a countershaft through a high-speed chain. A second chain runs from the countershaft to a pinion shaft that engages with two large gears. These gears are mounted on parallel main shafts that turn at 5 r.p.m.

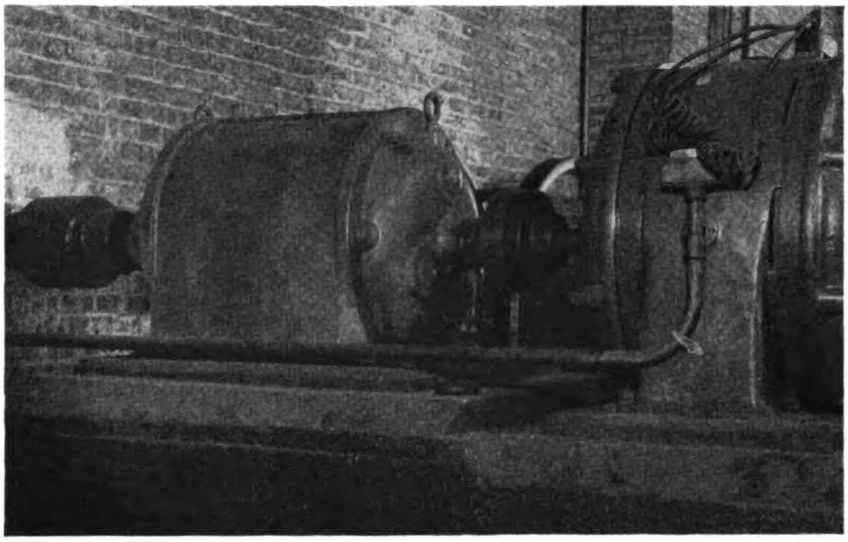
Although this drive arrangement gives the desired reduction in speed, considerable trouble is experienced on account of the short life of the chains. Operating conditions are severe and the average life of a chain is about 20 months. Naturally, this



This draw bench is driven by a 150-hp. motor through a Link-Belt chain operating on 38-in. centers.

On this application a speed reducer released about 70 per cent of the floor space required by the type of drive formerly employed.

This 120:1 ratio Jones reducer drives one of the machines in a steel fabricating plant. Two parallel, low-speed shafts on this machine, located on the other side of the wall, are connected by a short chain drive.



makes maintenance costs high. The amount of floor space required is also objectionable.

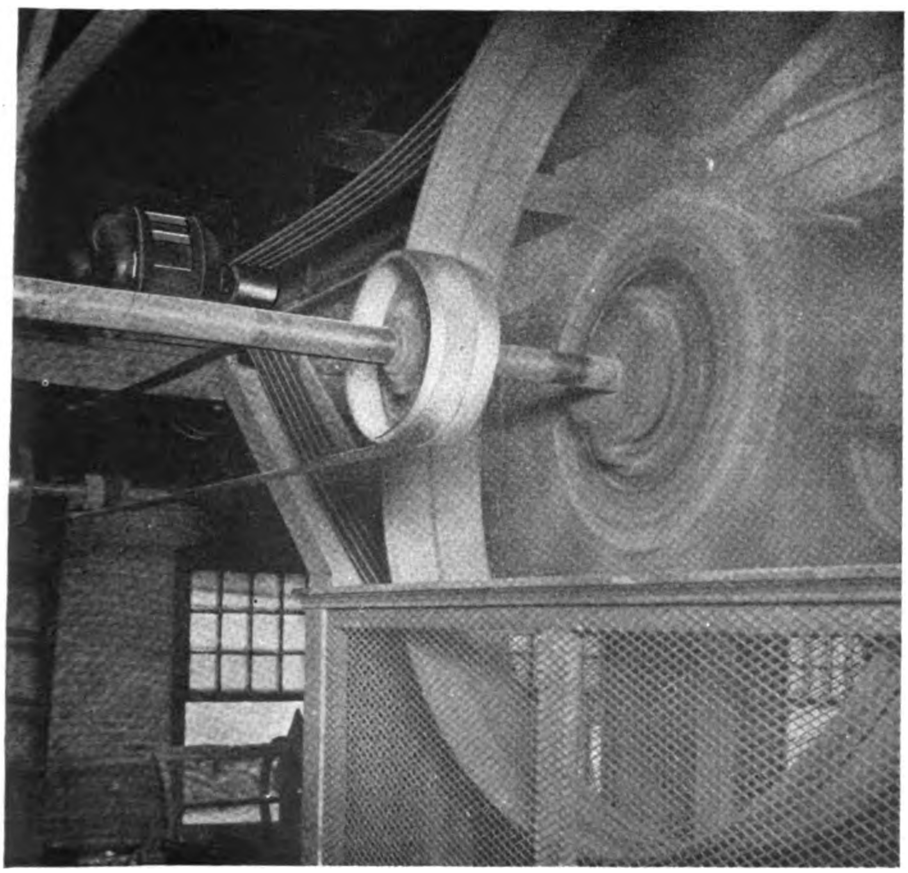
After a careful study of the requirements it was decided to install a Jones speed reducer to drive the new machine. This installation is shown in the illustration. The two parallel, low-speed shafts on the machine are connected, on the other side of the wall, by a short silent chain drive.

This drive has given entirely satisfactory service at low maintenance cost, and occupies only about 30 per cent of the floor space taken by the drive on the other machines, although it is of larger capacity.

J. L. DE RABOT, *Consulting Engineer, Alexander Brothers, Inc., Philadelphia, Pa.*—Some time ago the erection of an addition to the main building of a button factory in Connecticut made it necessary to cut several large passage-ways in the main building. To do this a few pieces of equipment and also one 12-hp. motor and a jackshaft had to be rearranged. It was eventually decided to put the motor up near the ceiling. However, considerable difficulty was experienced in properly locating the jackshaft. Direct drive was seriously considered, as the distance between the motor and main shaft drives was only 9 ft., and a large reduction in speed, which required a pulley ratio of 12:1, was needed in order to obtain 100 r.p.m. on the main lineshaft.

Space for a passage-way was obtained by replacing a jackshaft with this open belt drive operating on 9-ft. centers.

The pulleys on which this Tentacular belt runs are 7½ in. and 90 in. in diameter respectively, giving a speed reduction of 12:1.

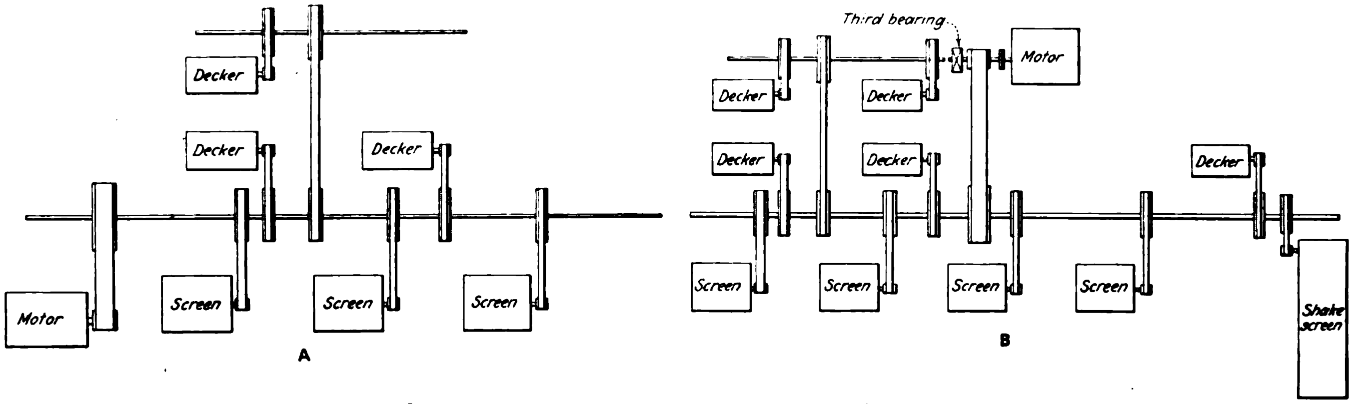


After investigating several different types of drives, it was finally decided to try an open belt drive, using a 7-in. Tentacular belt, as shown in the accompanying illustration. The driving pulley is 7½ in. in diameter, and the driven pulley is 90 in. in diameter. No trouble has been experienced with this drive and it is giving much better satisfaction than the old, which included a jackshaft. The new short-center drive has made available space for the passageway.

H. E. STAFFORD, *Electrical Engineer, Provincial Paper Mills, Ltd., Port Arthur, Ont., Can.*—Of the various changes that have recently been made at our plant, the one that is described below required the most thought and effort.

In connection with our groundwood mill we originally employed three centrifugal screens, requiring approximately 17.5 hp. each and three deckers or washers requiring 5 hp. each. They were driven as shown at *A* in the accompanying illustration. A 125-hp., 514-r.p.m. wound-rotor induction motor that had previously driven a 1,700-lb. beater was available for the drive, and was belt connected to a lineshaft, which was about 60 ft. in length.

This motor was first installed at one end of the lineshaft, and connected to it by a 14-in. double leather belt. The load on the motor was about 75 hp. It was found impossible, however, to run the various machines at their proper speeds owing to the belt slippage due to the short center distance—14 ft.—between shafts. In order to prevent slippage it was necessary to tighten the belt to such an extent that there was excessive wear on the belt and also on the motor bearings.



This shows the original layout, *A*, of the drive for the ground-wood screens and, *B*, how the drive was re-arranged to overcome operating troubles.

Recently it was desired to drive from this lineshaft one more screen, which was then being driven by a 20-hp. motor, two more washers, and a shake screen. After considerable study and discussion the following changes in the layout of the drive were made.

The motor was shifted so that the drive came in the center of the lineshaft as shown at *B* in illustration. The belt width was increased to 24 in. and the distance between centers increased 6 ft., making a total of 20 ft. The motor was equipped with an outboard bearing, making a three-bearing arrangement. A larger pulley was placed on the motor, which allowed the speed of the various machines to be increased to the maximum.

After all the old as well as the new equipment was placed in operation, the load on the motor was found to be 130 hp. This represents only a slight overload, which the motor is able to carry with a rise in temperature of only 30 deg. above the room temperature.

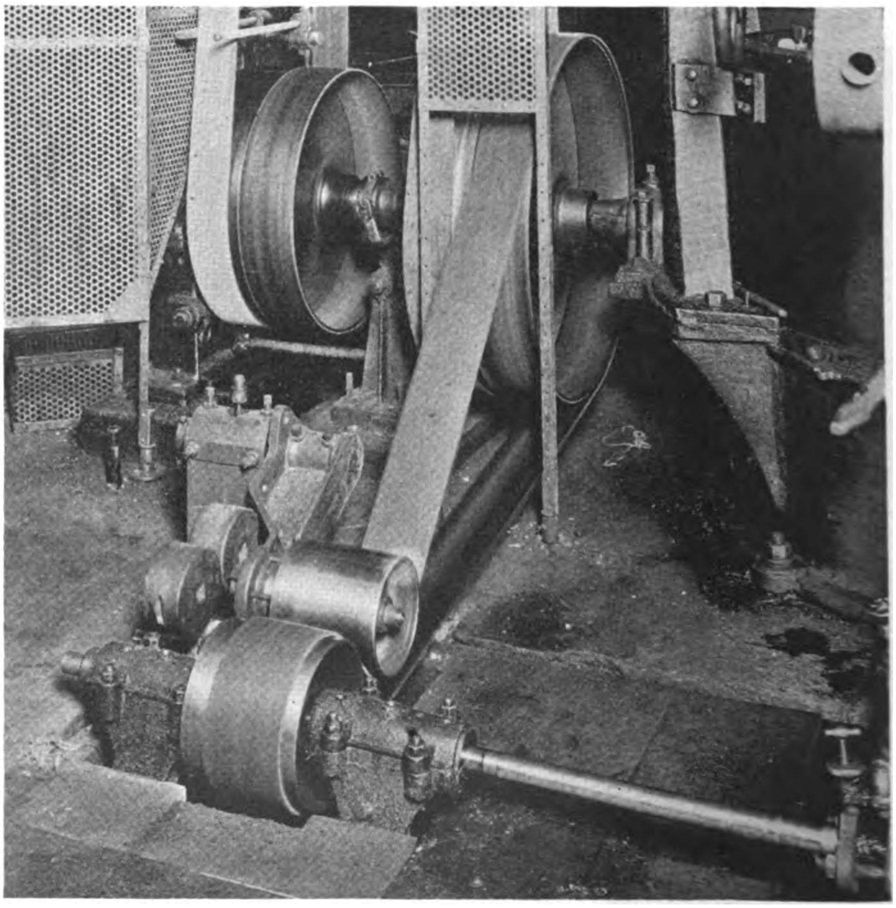
As the result of this change the production of screened ground-wood has been increased from 50 to 80 tons per 24 hr., and we have had no more belt trouble due to slippage or other causes.

STANLEY HASTE, *The Bird Machine Co., South Walpole, Mass.*—A great deal of trouble was experienced with the drive for a dye pump in a textile mill, due to excessive belt slippage. Slippage, in turn, was caused by the small arc of contact on the motor pulley. This was an open belt drive operated by a 15-hp. motor and in order to keep the pump going the belt had to be kept so tight that it was under a very abnormal tension. Friction in the bearings was correspondingly increased and because of the undue heating all of the bearings and the pump packing had to be watched closely, in order to avoid the necessity of shutting the pump down during working hours. Naturally the bearings and packing had to be renewed frequently. Furthermore the operating conditions were so severe that the driving belt had to be replaced about every six months.

In order to improve the operating conditions several changes were decided upon. First, the flanged pulley then in use was removed and a standard cast-iron pulley was installed in place of it. Then, after a new belt was put on, a Pulmax drive was installed to increase the arc of contact on the small pulley. Increasing the arc of contact will frequently improve the operating efficiency of a belt that is well loaded, regardless of whether it is operating on a long or short center distance.

When the arc of contact is increased a belt can carry its load with less tension on it. Consequently, it was found possible to reduce the tension on the dye-pump belt to the point where bearing heating and wear were entirely normal. No further trouble has been experienced with this installation.

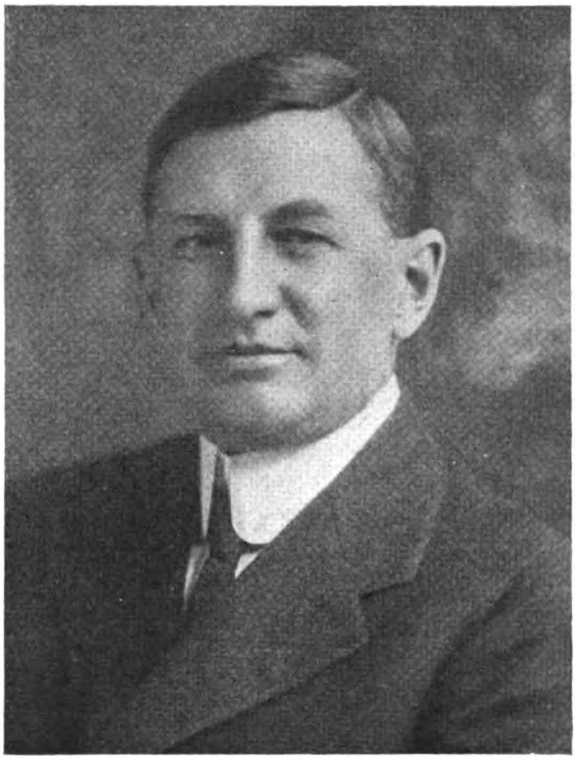
Increasing the arc of contact by the use of a Pulmax drive made it possible to reduce the tension on the belt and thus eliminate both belt and bearing troubles.



Study Your
Power Transmission Problems

By F. H. WILLARD
President,
Graton & Knight Company, Worcester, Mass.

ALL the factors involved in the transmission of power are constantly changing, and have been changing for the past twenty-five or thirty years; hence a principle that is applicable today may not be applicable tomorrow. For this reason, a study made for economic reasons when a plant was erected is not satisfactory as a guide to all future action. It is necessary for the manufacturer to keep his problem in mind constantly, and watch for new developments, if he is to keep his methods thoroughly up to date.



F. H. WILLARD

The development of the motor and of machine tools has been making rapid strides, and will continue to progress. At the same time, manufacturers of the older forms of transmission equipment are constantly improving their product, and these improvements should not be left out of consideration, nor disregarded in the light of conditions which existed in the past. Competition between the various forms of transmission equipment will tend increasingly to spur all manufacturers thereof to greater endeavors, in order that each may maintain or increase his own standing in the field. The off-hand installation of forms of transmission equipment, which at first glance may appear to be panaceas for all kinds of transmission difficulties, should be discouraged. No such panacea has as yet stood the test of universal and continued application. The very nature of the transmission problem, involving as it does widespread and often conflicting phases, indicates the impossibility of the development of any such cure-all.

The cost of power transmission, however, has been given little or no scientific study. Sales talk has, in many cases, brought about expensive changes that have resulted in a higher, rather than a lower, cost of transmission. This action has many times been taken without any disposition to investigate the cost of the older types of transmission, and improve them, as they may be readily improved.

The question of power transmission is worthy of a real, scientific study, commencing with the equipment already in the plant and studying methods of improving it, as well as proper installation and upkeep. Power transmission equipment is too frequently allowed to run on and on without any attention other than oiling of the bearings; whereas, if a suitable organization had charge of this equipment, and it were given the same careful attention that many of the production machines are given, thousands of dollars would be saved in power consumption, and thousands more would be made in increased production. There is a proper place for every form of power transmission equipment that is on the market, but no equipment of any kind should be installed without first studying carefully its adaptability to the job. Any amount of study and engineering skill is displayed in selecting the proper power unit and the proper production machine, but little or no study is given to the selection of the best form of transmission between the two.

In short, the determination of the proper transmission equipment should include a comparison of the power consumption by various units. To make this comparison, technical and scientific research is absolutely required. If the study is to produce accurate results, it should include:

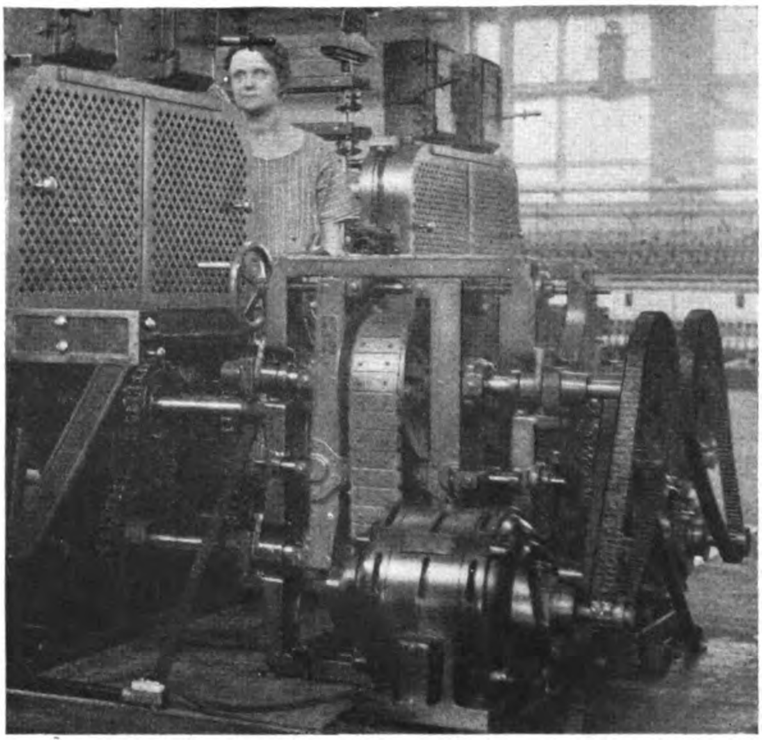
The original cost of the drive installation, so that the merits of all drives may be considered from the standpoint of the individual plant. There should be comparisons of the frictional losses, upkeep costs, frequency of replacements and relative costs and of the probable amortization values.

It is necessary to make studies of the ease with which changes may be made should conditions warrant the adoption of another system, and the facilities for quick repair in case of breakdown, with consideration of savings that might result from elimination of abuse of the equipment. Many other points will need consideration from the standpoint of the individual plant or industry.

To the end that complete and impartial studies may be made, without prejudice for or against any particular form of equipment, an organization known as the Power Transmission Association has been formed, which will comprise the leading manufacturers in every branch of this field. It has a capable board of engineers, representing, not the transmission equipment manufacturers themselves, but a cross-section of the industries that use this equipment, and they will make exhaustive studies.

Buyers of transmission equipment who feel that they require the assistance of this association—and it is my opinion that most of them do require it—are invited to communicate with the secretary, Mr. W. S. Hays, Drexel Building, Philadelphia, Pa. No obligation is involved.

This is one of five twisters in a New England French-worsted mill that are equipped with two Lewellen variable-speed transmissions driven by 5-hp. motors.



These transmissions make it possible to obtain any speed between 750 and 8,000 r.p.m. required by the size and twist of the yarn that is being made.

How Problems in Variable-Speed Operation have been solved

IN THE operation of many types of production machines, it is necessary to provide some satisfactory means of varying the speed at which the machine is driven. Textile machinery is a well-known example of a class of equipment that frequently requires to be driven at different rates of speed. For example, it is necessary to start silk throwing and winding frames slowly and gradually bring them up to speed in order to avoid breakage of the fibers.

A requirement encountered in several different industries is that of winding paper, cloth, wire, linoleum, or other flexible material on to rolls and gradually decreasing the speed of the roll as it increases in diameter. In other words, it is necessary to regulate the speeds so that the roll will always wind the same number of yards per minute.

In some of these cases the material is coming from a production machine at a given number of feet or yards per minute. The winder must synchronize exactly with the production machine. In other instances the goods or material is wound from one roll to another for the purpose of inspection or for some finishing process.

It is also necessary, or desirable, to vary the speed of assembly conveyors, which are widely used in automobile plants and in various industries, in order to meet varying production demands or to give the men a chance to become "warmed up" in the morning before maximum production is attained.

Briefly, variable speeds may be obtained either electrically, by the use of a variable-speed motor and suitable control, or mechanically, by the use of some simple device such as step or cone pulleys, or by employing what are commonly known as variable-speed transmissions. These are of two general classes or types.

One of the well-known types of mechanical variable-speed transmission consists essentially of two pairs of movable, cone-faced disks mounted on parallel shafts and connected by some form of belt, which drives from one pair of disks to the other. Levers are provided for moving the disks so that as one pair approaches the other pair separates. The diameters of the disks are thus changed and the speed ratio modified. Slight shifting of the disks makes it possible to obtain a wide range of speeds in a large number of steps.

In another type of mechanical variable-speed transmission that has recently been developed, change in speed is obtained by shifting the position of rollers on a cone-shaped race.

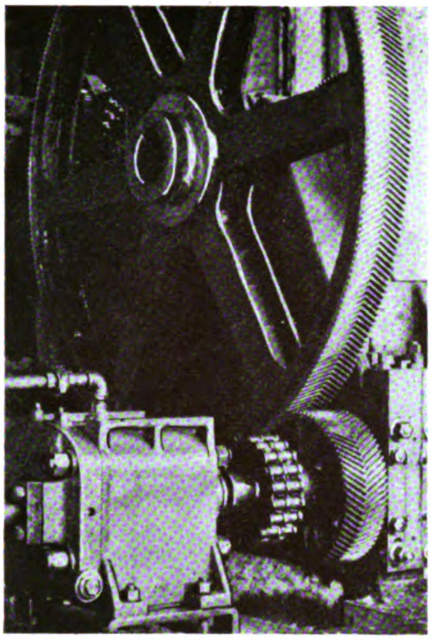
Several makes of hydraulic variable-speed transmissions are also available. In general, these consist of a pump, operated at full speed by the driving motor, that can be adjusted to force a varying quantity of liquid, usually oil, into a companion unit, which is thus driven as a motor at a varying speed, that depends on the quantity of liquid received. Most of these hy-

draulic units can be adjusted to deliver speeds ranging from zero to the maximum speed of the pump unit. Also, the low-speed unit can be made to operate in either direction, although the pump unit is driven at a constant speed in one direction.

The problem of obtaining a sufficiently wide range of speeds, and controlling these easily and accurately, is oftentimes a difficult one to solve satisfactorily. Details of how this problem has been solved in various installations are given below.

D. R. FRANCIS, *Chief Engineer, The Waterbury Tool Co., Waterbury, Conn.*—In the manufacture of paper it is necessary to vary the speed of the machine within wide limits. This requirement presents some practical difficulties that have been the subject of a good deal of study. The manner in which we solved one interesting problem of this character is indicated in one of the illustrations, which shows an installation of one of our hydraulic variable-speed gears driving the variable-speed line of an 86-in. paper machine at the Parsons Paper Co., Holyoke, Mass.

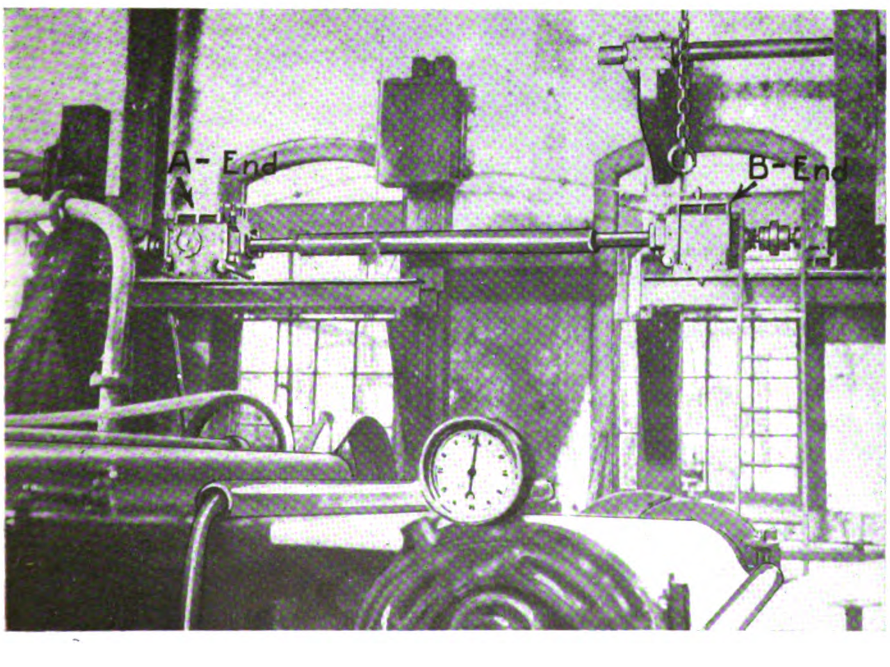
The variable-speed line of a paper machine extends the entire length of the machine. The several sections of the machine are driven by belts over cone pulleys from this variable-speed line. The slight difference in speed to compensate for stretch or shrinkage of the paper between sections is taken care of by the location of the belts on these cone pulleys. The speed of the variable line, however, is varied over a wide range corresponding to the different weights of paper manufactured. For a heavy paper



the speed is slow; for a light paper it is high. To convey some idea of the range of speeds necessary we might mention that on one machine for which we have furnished a drive the paper made varies from a tissue of about 11 or 12 lb. to a bristol board, running as high as 185 lb. A very considerable portion of this change in weight is accomplished by varying the speed of the paper machine. This requires a corresponding variation in the speed of the variable-speed line.

The range of speeds on the variable line shown in the illustration is approximately 10 to 1. The A- or pump-end of the hydraulic variable speed gear is located at the left side of

This shows a hydraulic variable-speed gear on the variable-speed line of an 86-in. paper machine.



Here is an application of a hydraulic variable-speed gear to a veneer lathe.

the illustration, and is driven by a silent chain from the constant-speed line, running along the floor. This constant-speed line, in addition to driving the A-end, drives all of the constant-speed equipment, such as pumps, screens, shakes, etc. There is a very decided advantage in being able to use one source of power for operating both lines of the paper machine, as it makes possible one large instead of two small power units, thereby reducing both the initial expense and maintenance.

The A-end of the variable speed gear is driven at a constant speed. The volume of oil displaced by the pump is proportional to the setting of the control shaft, and the displacement of oil governs the speed of the B-end. The B-end of the unit is located at the right, and drives by a silent chain the variable-speed line which is overhead, the speed of the variable line ranging from 0 to about 165 r.p.m.

Piping is used to connect the two units, and this piping is jacketed for cooling purposes. Some cooling is necessary on any installation running in continuous service.

Another unique variable-speed application can be seen in the other illustration, which shows an installation made in a Western veneer mill. In this case the B-end of the hydraulic variable-speed gear is direct-connected through herringbone gears to the main spindle of the veneer lathe. By this means the speed at which the log is rotated is governed over a very wide range. By connecting the control shaft of the A-end to a cam on the end of the log the speed of rotation can be automatically governed by the size of the log. As the log is reduced in diameter its speed of rotation is increased so that veneer is cut at a constant cutting speed.

It has been found that in this way it is possible to cut the logs to a very much smaller diameter than was originally possible, resulting in a very considerable reduction in waste. Also, due to the fact that the cutting speed is constant the production is greatly increased. It has been found possible to use profitably logs that were much too small to be cut by previous methods. This has made possible the use of timber that could not be economically used before, and due to the fact that the small trees are usually of a better grain and sounder, better veneer is produced.

E. W. SEEGER, *Engineering Dept., The Cutler-Hammer Mfg. Co., Milwaukee, Wis.*—The use of powdered fuel in boiler plants has given a decided impetus to the use of automatic control and has presented some interesting problems in variable-speed operation.

One of the difficult problems in connection with an installation of this kind is the design of satisfactory fan controllers, particularly on the induced draft, which requires a larger unit than the forced draft.

The illustration shows the induced draft fan controllers recently installed by a large utility company and used in connection with four two-speed, 550-hp., 450/900-r.p.m. slip-ring motors. Sixty speed points were required, with a total range in speed of 9 to 1.

The equipment for one fan is shown here set up on the test floor. The master unit *A* is supplied with a pilot motor drive responsive to changes in steam demand. This drive in turn controls the secondary resistance drums *B* and *C* by means of the chains shown. Electrical interlocks are provided in the drums which allow closure of the air-break, electrically-operated primary circuit breaker only when a sufficient amount of resistance is inserted in the motor secondary.

The switch *D* is a multi-pole, two-position, motor-operated device used for transferring the motor primary and secondary resistance connections from low to high speed. The pilot motor of the transfer switch drives a cam which moves through 180 deg. at each operation, opening one set of motor contacts and closing the other. The motor drive is supplied with a handwheel for unmeshing the gears and a handle for emergency manual operation.

In order to avoid any possible motor trouble at high speeds where the load is heavy, the resistance is balanced on the last five controller points. Contacts on drum *C* control the motor-operated drum *E*. A small motion of controller *C* causes an extended and rapid motion of drum *E* which is stopped when the contact fingers are making full contact on their related segments.

The total speed range of the equipment is 9 to 1. A 2 to 1 reduction is obtained by reconnecting the motor windings, and the remainder by secondary resistance in the low-speed connections.

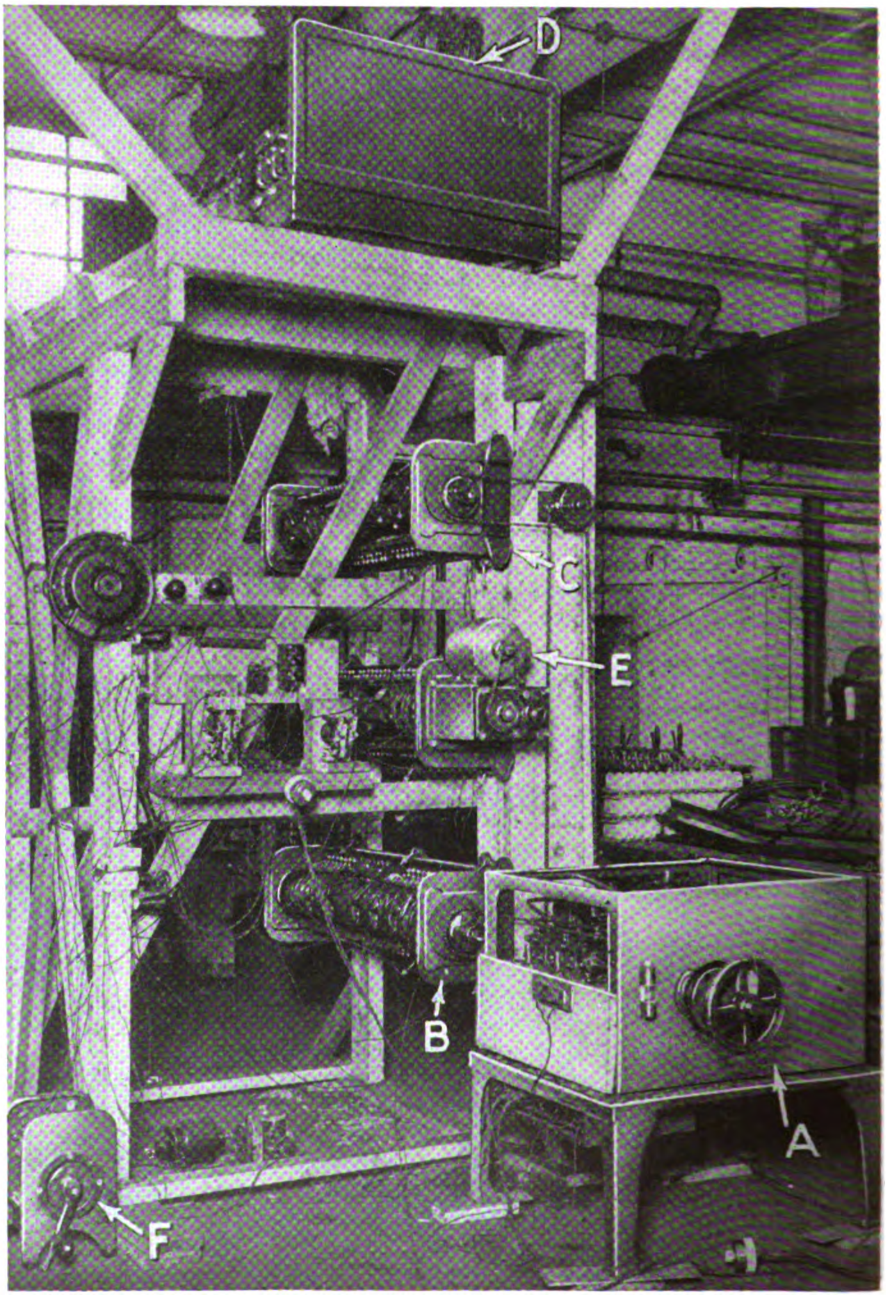
With all of the speed-regulating resistance in circuit, the starting torque is limited and the motor-operated drum *F* is provided to insure starting. This drum makes one-half revolution when the equipment is energized, short-circuiting a portion of the regulating resistance and reinserting it when the motor is under way. If the fan motor stalls at any time on the low speed, drum *F* operates and causes restarting.

In operation, when a boiler is placed in service, the demand for steam causes the master unit, *A* to start and open the dampers, thus utilizing natural draft. On further demand for steam, the master unit starts to revolve drum *B*. Drum *F* and the primary circuit breaker then operate, starting the motor. As drum *B* revolves, secondary resistance is short-circuited and the motor speed increases.

Just before drum *B* reaches its limit of travel, drum *C* also starts to move, interrupted gears in unit *A* being used to start and stop the drums at the proper points. On the last point of drum *B* a contact is made for the pilot motor on the transfer switch *D*, which opens the low-speed primary connections, inserts the high-speed secondary resistor and closes the high-speed connections.

Further movement of master unit *A* causes the high-speed drum *C* to revolve and short-circuit the secondary resistance. As the fan approaches maximum speed, drum *E* is brought into play and the resistor is balanced on the last few points.

Induced draft fan controllers for two-speed slip-ring motors, giving a speed range of 9 to 1.
The illustration shows this Cutler-Hammer installation on the test floor.



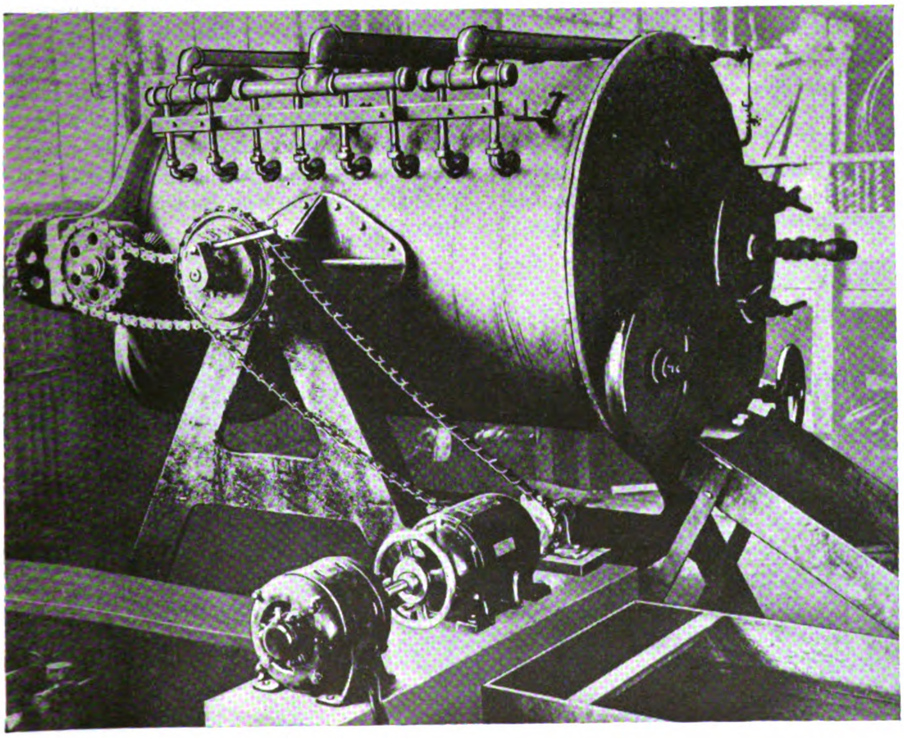
If the demand for steam decreases, the reverse operation takes place. The resistance in the high-speed winding is first increased until the speed is slightly below the synchronous speed of the low-speed connection. In its final position drum *C* causes the transfer switch to operate and connect the motor for low-speed operation. Drum *B* then inserts secondary resistance and reduces the fan speed. Eventually, drum *B* is stopped in its final position and further operation of unit *A* causes the motor to stop.

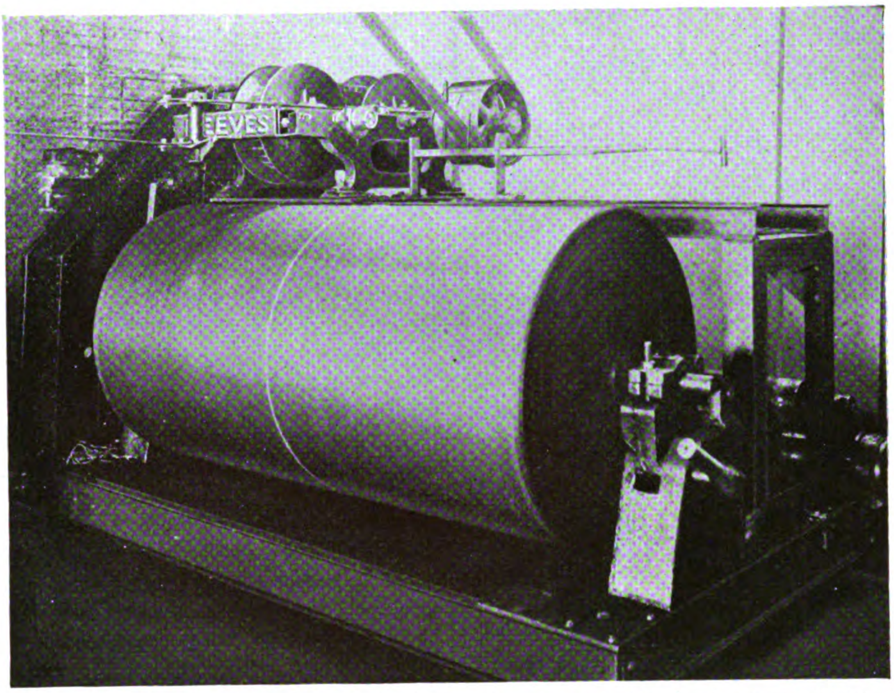
C. H. ADAMSON, *Stephens-Adamson Mfg. Co., Aurora, Ill.*—In the successful operation of a carburizing furnace it is often necessary to vary the slow rotation of the drum within a range of from one to five revolutions per minute, approximately. To facilitate this control it is highly desirable to be able to change the speeds at will and with minimum effort on the operator's part.

The illustration shows an installation in which the constant-speed electric driving motor shown at the left is direct-connected to a JFS variable-speed transmission which in turn drives the rotating mechanism for the revolving drum through a chain.

The speed variation is secured through the JFS speed unit which gives the desired control of the rate of rotation of the drum by manipulation of the small handwheel, that can be seen mounted between the motor and the variable-speed transmission.

Variable-speed drive for a carburizing furnace.
The revolving drum is driven by a constant-speed motor through a JFS. variable-speed transmission.





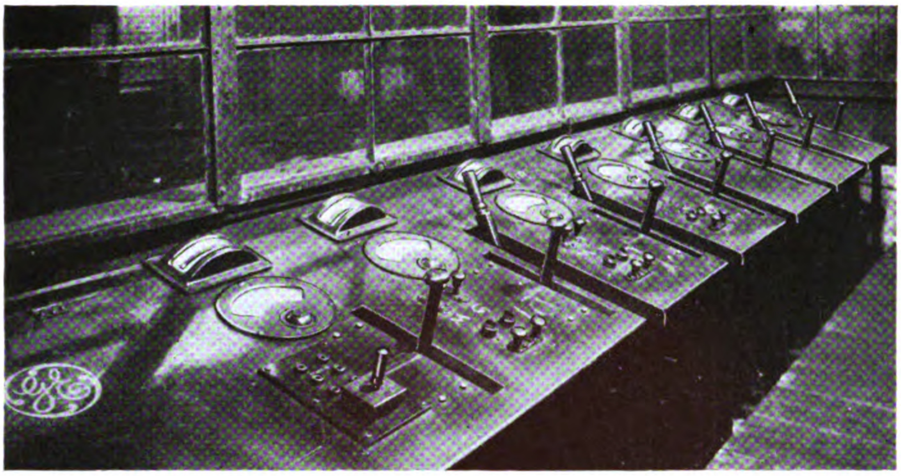
Reeves variable-speed transmission driving a winder in the plant of the Cott-a-lap Co., Somerville, N. J.

R. F. REEVES, *Reeves Pulley Co., Columbus, Ind.*—In the textile industry, as well as in others, there are a number of applications that require variable speed. One example of this is found in winding operations in which material is wound on a roll as it comes from the machine, or is transferred from another roll for one purpose or another. The problem of securing a uniform peripheral speed of a roll of cloth or other material that is constantly increasing in diameter, is an interesting one.

The illustration shows a Reeves variable-speed transmission in operation in the plant of the Cott-a-lap Co., Somerville, N. J. In this case the extended lever type of transmission is used, in which a follower roll bears against the roll of goods. This follower roll is connected to the extended lever of the transmission. As the roll of goods increases in diameter the follower roll is carried outwardly with it and in so doing moves the extended lever so that it gradually decreases the speed of the transmission, which, of course, controls the speed of the roll. When the roll is completed a balance weight returns the extended lever to its original position ready to start winding another roll.

Production on a roll equipped with a variable-speed transmission can be greatly increased over the volume possible where the peripheral speed varies in accordance with the increasing diameter of the roll. As an example, in one installation the operator has found it possible to fill the roll in 7½ min. whereas it formerly required 16 min. This represents a saving of approximately half of the time required heretofore.

The same general problem has been solved in several other cases by the use of our electrical automatic transmission. In this type of installation the automatic switch has an operating lever that is connected to a follower roll.



Operating pulpit showing control board for 21-in. continuous sheet bar and skelp mill.

R. H. ROGERS, *Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.*—Many problems in variable-speed operation are encountered in steel mill service. Not only are the requirements exacting, but in this industry the magnitude of the equipment and the amounts of power handled are of such magnitude that careful attention must be paid to efficiency of operation and many other details.

Some interesting and unusual problems were recently met in designing the control and drive equipment of a 21-in. sheet bar and skelp mill consisting of ten 2-high stands in line for continuous rolling. The requirements were somewhat complex in that although the equipment could be loosely grouped into roughing, intermediate, and finishing stands, the work might be completed in as few as three stands or any other number up to the whole ten.

The roughing and intermediate stands, seven in all, in groups of three and four respectively, required adjustable-speed operation, but not of particularly fine adjustment. The three finishing stands were required to operate independently through a wide speed range capable of rapid fluctuations under rapid and precise control, because of the high speeds attained together with the necessary control of the loops of hot metal between stands.

It was decided to drive the roughing and intermediate stands with induction motors. The first required a 3,600-hp. motor at 290 r.p.m. down to 1,940-hp. at 156 r.p.m. The second required a 7,500-hp. motor at 250 r.p.m. down to 4,040 hp. at 134 r.p.m. Rheostatic control would result in enormous energy losses because of the great power and speed range required. Again, the power factor of slow-speed induction motors is naturally very poor and means for its improvement is required.

The required speed range and quality of control as to rapidity and precision indicated direct-current motors for the three finishing mills; hence they were powered with 2,000-hp. 85/165-r.p.m., 600-volt motors.

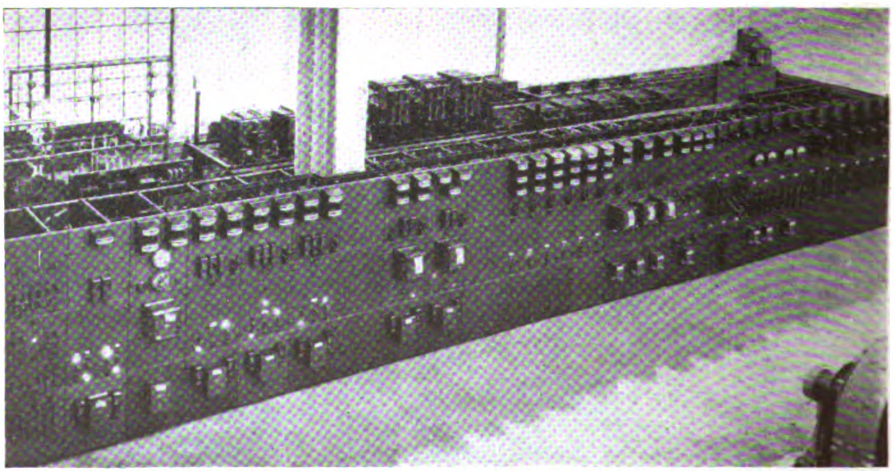
The power supply is 2,200 volts, three phase, 60 cycles and the induction motors are directly connected to this supply. Three synchronous motor-generator sets were supplied: each consists of a 4,400-kva. synchronous motor driving two 1,700-kw., d.c. generators. Only three of the generators are required to drive the three finishing stand motors which are controlled by the Ward Leonard system: that is, by generator voltage control. That leaves three d.c. generators to be accounted for later.

The induction motors on the roughing and intermediate stands are controlled by a modified Kraemer system. The normal Kraemer system of speed control for an induction motor transforms the slip energy of the induction motor to d.c. power through a synchronous converter and then applies that power to the induction motor shaft by means of a d.c. motor. In some cases the d.c. power is used to drive a motor-generator set to return a.c. power to the line.

In this installation it was found expedient to return the d.c. power (derived from the induction motors by way of the synchronous converters) to the synchronous motor-generator sets in order to relieve the synchronous motors of at least part of their loads coming from the finishing stand motors. The partly-loaded synchronous motors thus furnish a substantial amount of leading kva. for improving the power factor of the whole plant. Power factor of the individual induction mill motors is improved by varying the field excitation of the synchronous converter to advance the phase angle of the counter-emf. The power factor of this mill is 97 per cent at full load and maximum speed. At full load and minimum speed it is 94½ per cent. At less than full load at any speed the corrective kva. is still greater.

The speed of the mill induction motors is adjusted by the apparently round-about method of varying the field strength of what are now the d.c. motors on the synchronous motor-generator sets. By strengthening the motor field the counter-emf. is increased and acting through the converter it bucks down the secondary voltage of the induction motor and hence causes it to slow down. In this way any variation in the relatively small field current of the d.c. motor results in an immediate, corresponding speed change in the 3,500- or 7,500-hp. induction motor as the case may be.

This shows the switchboard for the electrical equipment of the 21-in. continuous sheet bar and skelp mill.



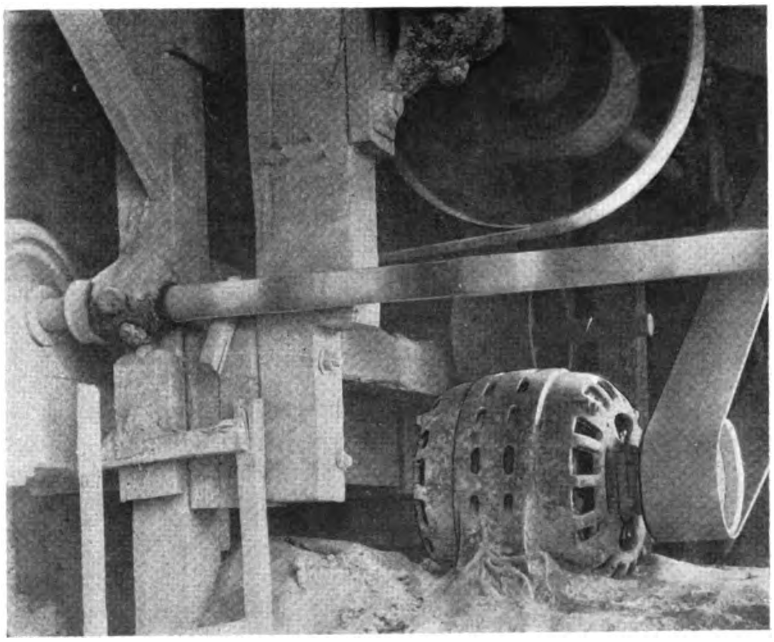


Fig. 1—A typical example of power transmission where much dust and foreign matter is present.

Under such conditions the utmost care is required in the selection of suitable lubricants.

Lubrication

of power transmission equipment

By ALLEN F. BREWER
Mechanical Engineer,
The Texas Co., New York, N. Y.

IN THE operation of industrial plant equipment, bearing lubrication is a matter of prime importance. As a result, the selection of lubricants to suit the system of lubrication provided and the prevailing operating conditions should be undertaken in a most careful manner.

It can be appreciated that adequate lubrication is an absolute necessity for the efficient transmission of power. Abnormal wear of bearings may very easily cause pounding of shafting, with serious losses in efficiency due to the natural increase in friction. This would be indicated by an increase in bearing temperatures.

To discuss intelligently the subject of lubricants it will be necessary to consider for a moment the several methods most commonly used in the average plant for lubricating bearings. For this purpose these are discussed from the particular angle of their lubricating requirements.

With devices such as ring, chain and collar oilers, the lubricant is continually carried to the bearing surfaces from a reservoir which is part of the bearing housing. The distributing element which dips into the oil, rides on the shaft and as it rotates it carries with it a continuous supply of fresh oil.

To insure effective lubrication it is important that the reservoir be of adequate capacity to give the oil ample opportunity to rest, thereby making possible not only the settling out of sediment and other foreign matter, but also cooling to the requisite degree. As a rule the only way in which the oil in such a system is kept at the proper temperature is by radiation of heat from the exterior surfaces of the reservoir or lower part of the housing.

When the reservoir is of apparently insufficient capacity an auxiliary reservoir can oftentimes be installed. One way in which this can be done is to tap a hole and insert a short length of pipe into the lower part of the bearing, plugging the bottom end, of course, with a cap. Such a device has an added advantage in that it also acts as a collector of dirt or other foreign matter.

It is important to remember that oil which is carried to the top of such a bearing must be taken care of and returned to the reservoir as rapidly as it is delivered by the oil distributor. If this is not possible, oil will tend to accumulate in the upper part of the housing and ultimately be forced out of the bearing clearance spaces. In the case of an electric motor this is detrimental to the coils. In fact, certain authorities contend that in the steel industry, for example, oil-soaked insulation is a prevalent cause of motor troubles.

Loss of oil in this way, not to speak of other troubles, may also arise if the oil is carried at too high a level in the well, or if the ring or chain rotates at too high a speed. This will cause a splashing and churning of the oil, with the result that wherever there is any windage or draft through the bearing, the oil spray may be carried off.

To prevent the possibility of such action certain designs call for the use of baffles, throwers, or labyrinth packing. Such devices in particular prevent direct circulation of air from the outside and through the bearing. In company with proper grooving of the bearing metal to permit ready dis-

tribution and return of the oil, they are regarded as adequate assurance that the latter will function as intended and not find its way out of the bearing to cause motor trouble, or damaged goods, in the case of line-shaft bearings.

Most effective lubrication by means of such systems of lubrication is attained under normal temperature conditions by the use of a high-grade, straight mineral oil of approximately 150 to 200 sec. Saybolt at 100 deg. F. Before deciding on the viscosity of the oil to be used, the bearing construction should always be investigated. Oftentimes if oil returns are too small they may become clogged, causing heavier oils to overflow.

In view of the fact that such bearings may frequently be called upon to function under low temperatures, an oil with a low pour test should be chosen whenever possible. If this is approximately 0 deg. F., the oil will generally function satisfactorily. It must be borne in mind, however, that higher temperatures will oftentimes require additional viscosity to resist the thinning action of heat. Under such conditions, an oil of from 300 to 400 sec. viscosity or even higher should be used, depending upon the operating viscosity desired at the prevailing temperatures.

In brief, viscosity is a measure or indication of the relative fluidity of an oil at the specific temperature of test. It might otherwise be stated as that property possessed by an oil by virtue of which its flow is retarded due to the resistance offered by its component particles or molecules in moving past each other. Viscosity varies inversely with temperature. As a result, the higher the temperature the more fluid will an oil become.

It is, therefore, important to note the operating temperature when selecting an oil for practically any type of bearing or lubricator. For the purpose of standardization 100 deg. F. is frequently taken.

The term Saybolt refers to the type of testing device. This measures the time in seconds required for a certain volume of oil to flow through an orifice which is of standard size. When an oil is, therefore, referred to as having a Saybolt viscosity of, say, 300 sec. at 100 deg. F., it means that at a uniform temperature of 100 deg. F. 300 sec. will be required for 60 cubic centimeters of the oil in question to flow through the orifice of the Saybolt viscosimeter or viscosity-testing device.

Lubrication of Anti-Friction Bearings

From a lubrication point of view, ball bearings can be served either with oil or light grease according to the design of the bearing housings. Roller bearings will also function with oil or grease lubrication, but prior to the selection of a lubricant it is essential to study the type and construction of the rollers, as well as the design of the housing.

As a general rule, ball and roller bearings occupy a minimum of space, and require lubrication, inspection, and cleaning at very infrequent intervals, regardless of their type or service classification.

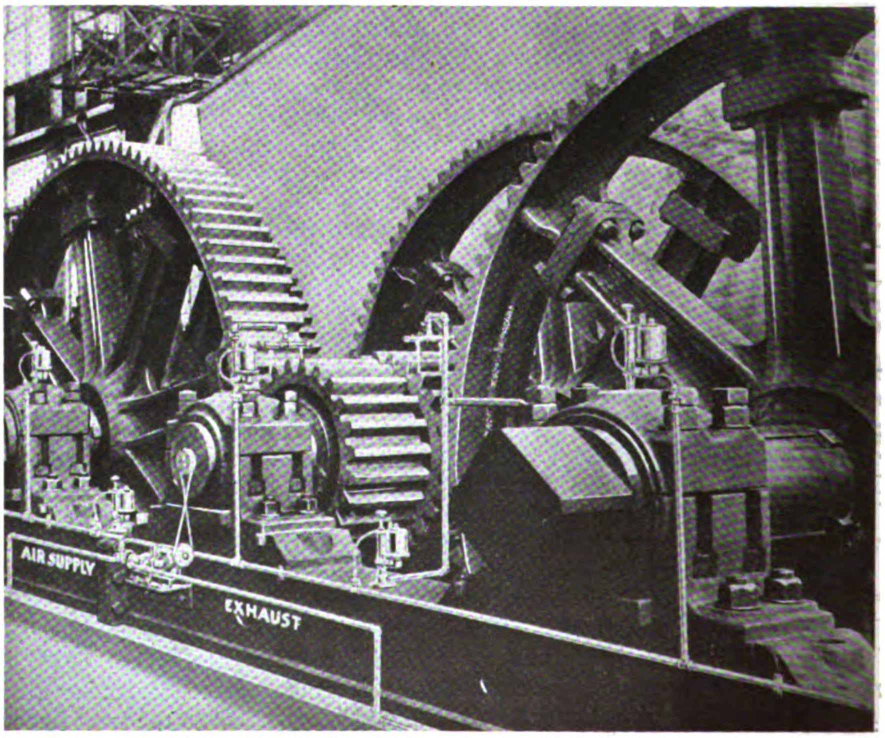
Anti-friction bearings involve rolling contact, as compared with plain bearings wherein sliding contact occurs. In ball bearings this rolling contact is that of a theoretical point over a given surface. Roller bearings, however, involve theoretical line contact between the journal or shaft element and the outer raceway. Their construction involves a set of perfectly spherical balls or an arrangement of solid or flexible rollers. The latter are cylindrical in shape, the distance between the inner and outer raceways being uniform throughout the length of the roller. Solid rollers, on the other hand, may be either cylindrical or tapered according to the type and design involved in their construction.

Regardless of the design of the rolling elements, however, these elements must be carried or housed in more or less the same way, using containers in the form of raceways and cages. The inner race fits on the shaft, the outer being held by the motor or hanger frame according to the type of installation. Between them are located the rolling elements. These are kept in their proper positions with respect to the races, and to each other, by the separator, cage or retainer. Rotation of the shaft sets up a rotary motion between the rolling elements and the respective inner and outer surfaces of the raceways.

The purpose of lubrication, of course, is to make rolling as easy as possible. To facilitate this, however, all the surfaces (which are highly polished) must be in as perfect condition as practicable. As a result, the lubricant must serve the dual purpose of both lubricating and protecting these surfaces against rusting, corrosion, pitting or abnormal wear. Minimum clearance, of course, of the parts, aids the proper functioning of such bearings, for any play between the component parts would tend to set up a certain amount of pounding which would be detrimental to effective operation. In brief, all motion must be as nearly akin to perfect

Fig. 2—Automatic lubrication is used on these exposed gears.

A comparatively heavy-bodied gear lubricant is used under air pressure. In this way all parts can be lubricated simultaneously at a saving in labor and economy in the use of lubricant.



rolling as possible if such bearings are to function as intended.

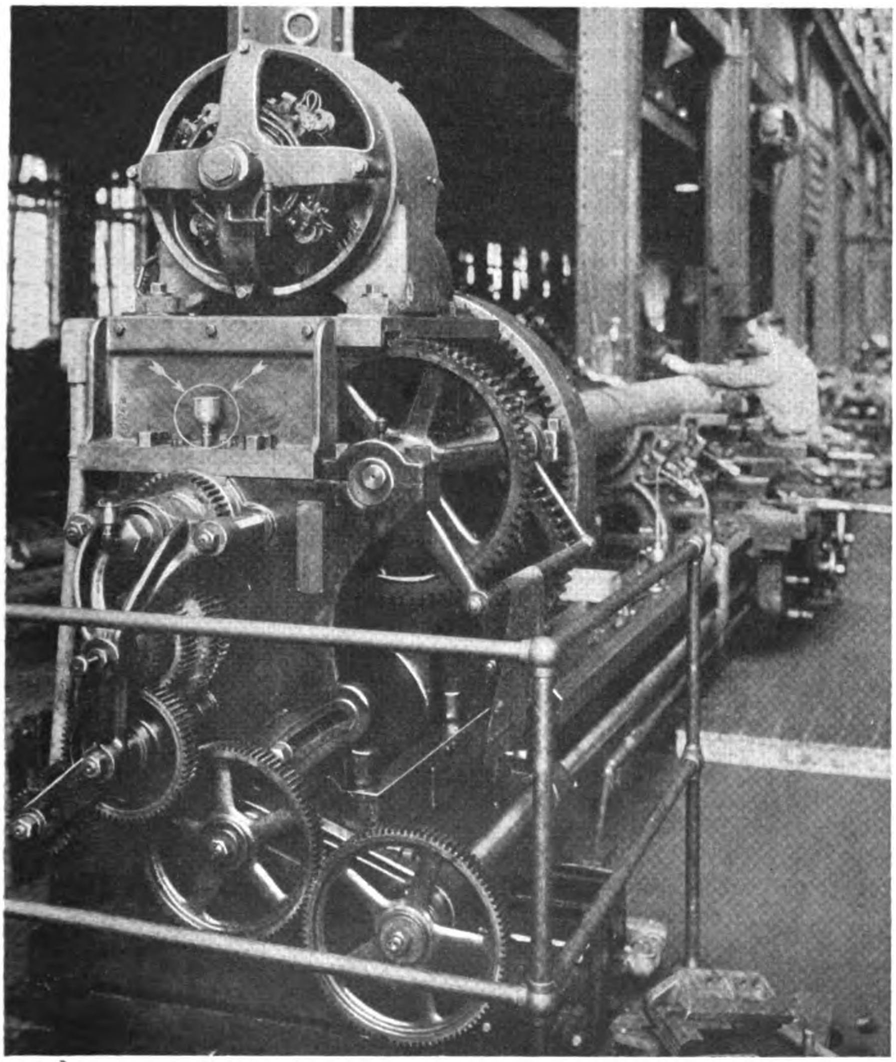
Experience has proved that as light a lubricant should be used as can be successfully retained in such a bearing, considering of course, the temperatures and pressures involved. In many installations, notably on machine tools, as brought out at the recent meetings of the American Society of Mechanical Engineers at New Haven, Conn., an oil of comparatively low viscosity will be best.

In this regard, ball bearings are claimed to involve less friction which is to a certain extent due to the fact that there is little or no end thrust involved. As a result the lubricant in such bearings serves more nearly the purpose of acting as a metal-protecting medium. In view of this fact, and to reduce the possibility of the development of abnormal internal friction within the lubricant, it is advisable to pay careful attention to the oil level. Certain authorities contend that submergence of approximately one-half to three-quarters of the lowest ball will be sufficient. It is, however, important to remember that contrary to the principles of plain bearing lubrication, the oil in an anti-friction bearing plays no part as a coolant. Therefore, a large volume of oil is a detriment rather than an advantage.

Lubrication of roller bearings by means of oil is subject to much the same conditions as stated in connection with ball bearings. Where end thrust may develop to an appreciable extent, due to difficulty in keeping the rollers in alignment, or where pressures or temperatures may be high, it will be conducive to better lubrication if somewhat heavier oils are used. On such bearings the use of straight mineral lubricating oils of as high as 750 sec. Saybolt viscosity at 100 deg. F. may be advisable. Even mineral cylinder oils of a high degree of purity may be necessary under conditions of extremely high duty, pressure, or temperature. The selection of heavier oils for roller bearing lubrication, however, should be carried out with the utmost care for it is possible to over-estimate the conditions of operation with the result that an excess of internal friction may be developed. Bearing temperatures in particular should be carefully observed.

Fig. 3—The gearing on this lathe is exposed to dust, dirt, and metallic cuttings.

An oil of sufficient fluidity to permit of ready application, and yet with enough body to stick and maintain a protective lubricating film on the teeth must be used. Certain of the gear shaft bearings are served by pin-type grease cups as indicated by the arrows.



The use of grease, in turn, will usually be advisable wherever there is a possibility of oil leakage, or under dusty conditions or where there is an excessive amount of dirt or dampness as shown in Fig. 1. Greases furnish better seals against the entrance of dust, dirt, and moisture, thereby serving to protect the polished surfaces of the bearing elements in a very satisfactory manner. Greases also can be very much more effectively retained in a non-oiltight housing; on the other hand, dirt or grit that finds its way into a grease-lubricated bearing has no means of settling out. It will therefore, be held in suspension, and carried through the bearing elements continuously, ultimately giving rise to more or less wear.

Greases that are comparatively soft in consistency will normally meet average operating conditions where the lubricant must readily cover the entire surfaces of the balls or rollers and not tend to channel in the housings or raceways, as might occur with more viscous products of this nature which would have less tendency to flow. On the other hand, where high temperature may prevail, as for example, in the case of certain steel or cement mill equipment, it may be necessary to resort to greases of greater body to withstand the thinning-out effects of heat, and to prevent any possibility of foreign matter getting into the bearing.

Greases for anti-friction bearing lubrication should be as free from acid-forming substances as possible, in order to insure adequate protection of the highly-polished metallic surfaces. In effect, this involves perfect neutrality, chemically and of course, the absence of fillers. It must be realized that the presence of any material that might give rise to oxidation and the development of free acidity, or to decomposition or settling, is always a detriment. Properly compounded products will meet the requirements satisfactorily and there should be practically no tendency for them to cause corrosion or pitting of balls, rollers or raceways unless op-

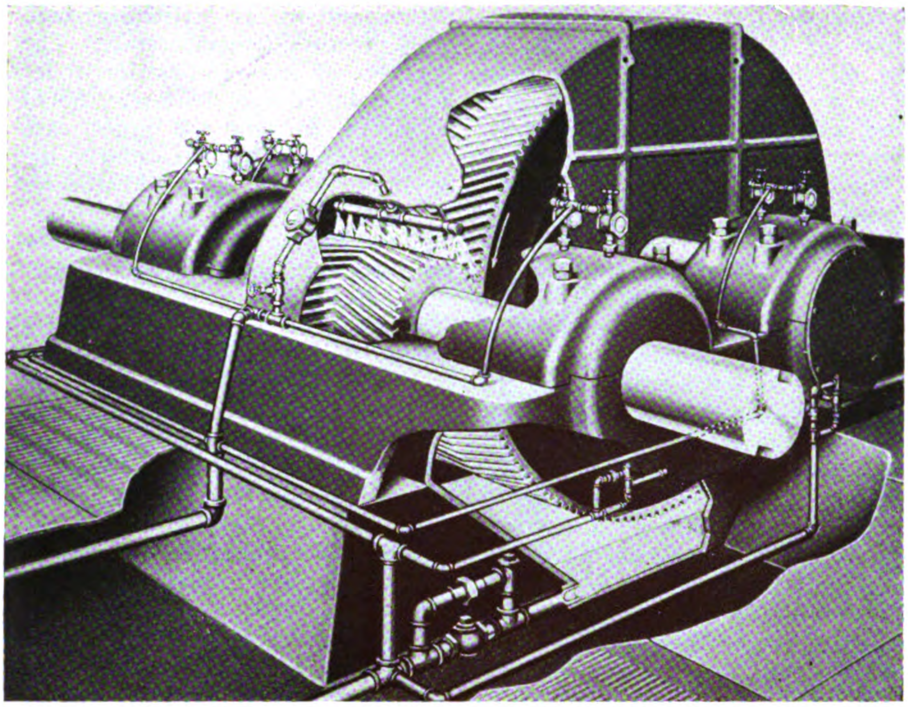


Fig. 4—This set of herringbone gears is lubricated by a circulating pressure system.

The nature of the housing and means of circulating the oil render effective lubrication possible, insuring against abnormal wear of the gear teeth and shaft bearings. The oil is delivered to the teeth as they go into mesh.

erating conditions are extremely abnormal.

As to frequency of lubrication it may be stated that, whatever the lubricant specified, a properly-designed ball or roller bearing will require replenishment of this product but once every three or four months, and oftentimes at less frequent intervals if the housing is capable of holding a relatively large volume of lubricant, and an effective seal is maintained to reduce leakage or contamination to a minimum.

Principles Underlying Lubrication of Gears

Lubrication of gears presents a different problem and may be said to involve a threefold purpose: the prevention of wear, the elimination of noise, and the reduction of power consumption. In many plants the gears of industrial machinery are neglected. They are oftentimes relatively large in contrast with the other wearing elements, and as in Fig. 2, may be massive. No wonder that their lubrication is neglected, especially where there is possibility of gear lubricant being thrown from unguarded elements as, for example, on certain types of metal presses.

Furthermore, many are prone to regard gear lubrication as of little consequence, on the assumption that the greater proportion of the motion involved is rolling. Sliding motion will always exist, however, and sliding motion imposes considerably more wear on the gear teeth than does rolling motion. In addition, as wear takes place sliding motion will supplant rolling motion in a constantly increasing degree. Irrespective of the type of motion, gear tooth friction will be reduced to a minimum if the lubricant has been properly prepared and is carefully applied. The result will be the reduction of noise, the elimination of vibration or chattering between the teeth and the prevention of abnormal wear in the average installation.

According to the type of service for which they are designed, gears may be built encased or exposed. As a rule this will depend upon the extent to which foreign or abrasive matter is present, or the requirements as to safety. Gears should always be guarded, but whether or not these guards are oil-tight will depend upon the importance attached to lubrication.

Oil-tight casings render bath lubrication possible and this in turn insures the utmost protection of the teeth, provided the oil is of sufficient body or viscosity to withstand the pressures to which the teeth will be subjected. In general an oil of from 100 to 200 sec. Saybolt viscosity at 210 deg. F. will be best for bath-lubricated gears.

On the other hand where gears are exposed, as in Fig. 3, a heavier product will generally be necessary, for the lubricating film must be capable of adhering tenaciously to the teeth, resisting temperature changes and the effects of speed and centrifugal force which tend to throw off the lubricant and leave the surfaces exposed to metal-to-metal contact.

The lubricant on the average gear installation performs an especially important function in that it serves to eliminate noise and vibration. The reduction of vibration is regarded by many as being just as essential as the maintenance of a lubricating film of proper thickness.

Herringbone gear trains, Fig. 4, generally run in a bath of lubricant or are equipped for pressure lubrication. In such installations it is frequently essential, or desirable, to use the same grade of lubricant on both gears and the adjacent bearings. For this purpose an oil of from 300 to 750 sec. Saybolt at 100 deg. F. should serve the purpose, depending on the severity of service, the size of the gears, and the design of the machine. Where such gears are bath-lubricated, however, it may often be more satisfactory to use a heavier-bodied product, with a viscosity range of from 100 to 200 sec. Saybolt at 210 deg. F. according to the size of the installation.

The lubrication requirements of bevel or angular gears differ but little from those of spur gears. In fact, the only difference in conditions will be in the relative amount of sliding and rolling motion. In general, the former will predominate, due to the greater difficulty that is frequently involved in the accurate cutting of teeth and alignment of the respective elements in assembly.

The lubricant should, therefore, be fairly heavy in order to meet these possible difficulties and to insure the maintenance of a sufficient film to take up any shocks involved, as well as to resist the wiping effects of such sliding motion as may occur during operation.

In turn, the lubrication of annular gears involves much the same requirements as encountered with spur gears. In fact, where they operate exposed, practically the same grades of straight mineral, semi-fluid lubricants as would be required on exposed spur gears should be suitable. It is interesting to note, however, that the effect of centrifugal force on an annular gear, is just the reverse of

that on a gear with externally cut teeth. As a result, there will not be the same tendency for the lubricant to be thrown off, except as it is taken up by the spur teeth of the driving pinion. Where such installations are designed for bath lubrication, a lighter, more fluid oil, selected with due regard for the pressures and size of the teeth, can be used to good advantage, thereby reducing the possibility of development of abnormal internal friction within the lubricant itself.

In the case of worm gear installations the manner of housing renders bath or splash lubrication generally possible. Operating and constructional conditions, however, will require a relatively wide variation in the viscosity of the lubricant to be used. For example, in certain instances a gear lubricant of approximately the viscosity of a straight mineral cylinder oil should be selected. In other cases a machine oil of from 300 to 750 sec. Saybolt viscosity at 100 deg. F. will suffice.

In all worm gear installations the level of the oil is of decided importance. The development of "drag" or excessive internal friction may become a decided factor in the matter of power consumption. As a result, the oil should be carried at such a height as just to insure suitable immersion of the teeth of the lower element. It is not advisable to submerge it too deeply.

The distribution of the lubricant from the teeth of the gear to the respective shaft and thrust bearings is usually provided for, although these can be lubricated externally if desired. Where the worm is located below the wheel or gear, the oil level should usually be carried at the center line of the worm shaft. Where the worm is above the gear, the gear teeth will carry less lubricant to the worm than the worm would to the gear teeth. As a result, a heavier, more adhesive lubricant may often be necessary, or the level of the lubricant may have to be raised in the gear case to a certain extent, dependent on the speed of operation.

Regardless of the type of gear, however, gear lubricants should in general possess certain definite properties if they are to function as intended.

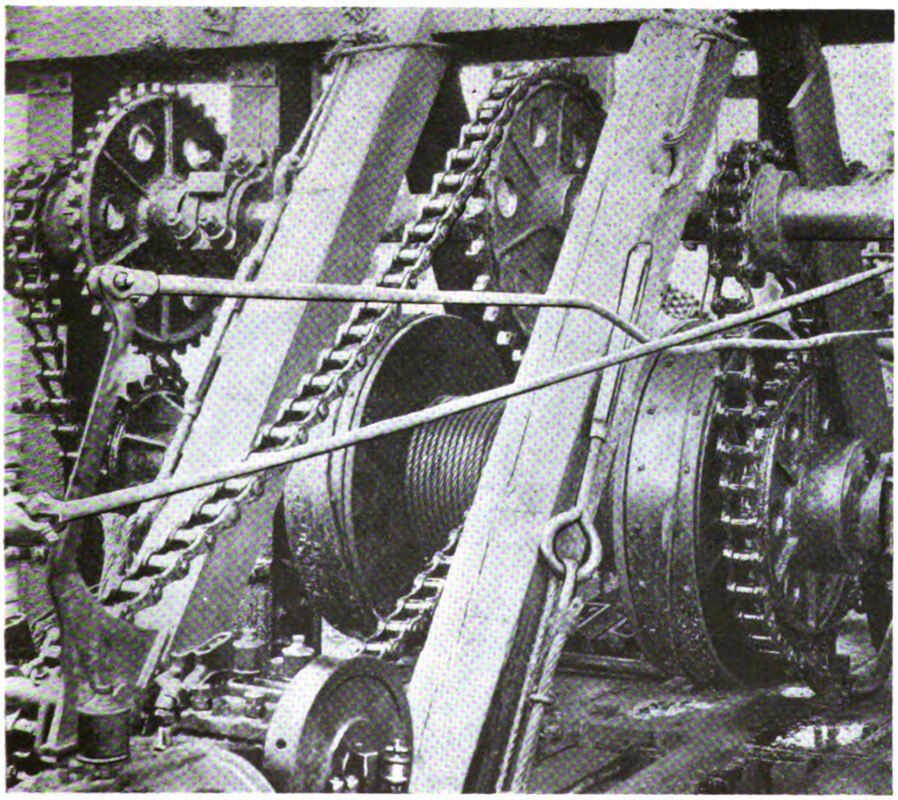
The viscosity should be commensurate with the method of lubrication and the amount of heat that may prevail in operation.

Adhesive qualities should be sufficient so that where the lubricant must be used under exposed or semi-enclosed conditions, the lubricating film will remain on the teeth and resist the tendency of centrifugal force to throw it off.

There should be little tendency to congeal, harden, crack or turn brittle when the lubricant is exposed to low temperatures; nor should such a lubricant carbonize when used under high temperatures, as in cement mills, for example.

Straight mineral lubricants will in general be found most capable of meeting these requirements on power transmission equipment, although blended or compounded products may frequently be offered for the purpose. In the case of the latter it is important to see that they contain no non-lubricating fillers. The purpose of using the latter would be to increase the viscosity or plasticity of the resultant product. On the other hand, they will frequently reduce the lubricating value. In addition, lubricants with such contents will lack to an appreciable degree the adhesive characteristics that may so often be decidedly essential. As a result, when they are used under exposed conditions, on high-speed gears subjected, perhaps, to the detrimental effect of water, acids or alkalies, the teeth may suffer materially due to the inability of these lubricants to resist the effect of centrifugal force, the washing action of water, or the corrosive effects of certain chemicals.

Fig. 5—The roller chain when exposed also presents a lubrication problem.
Effective lubrication is obtained by removing the chain periodically and immersing it in a bath of relatively heavy gear lubricant. The resultant film will prevent the entry of foreign matter.



Essential Requirements in Lubrication of Chain Drives

Chain drives for power transmission and speed reduction employ either the roller-type chain, Fig. 5, or the so-called silent chain, as shown in Fig. 6.

Cleanliness of operation is usually an essential feature of such installations, especially on overhead systems where the chains and sprockets are often exposed. Therefore, less lubricant will be needed, inasmuch as little or none of it will normally be thrown off by centrifugal force, even under higher speeds of operation.

Speed involves the frequency of shock due to engagement of the chain links with the gear or sprocket teeth. Whether such shocks will be detrimental to lubrication will depend upon the load and constancy of operation. It is natural to expect that the rapid repetition of such shocks upon the bearing points of the chain will tend to force or squeeze the lubricating film out from between the wearing surfaces.

It is impracticable to compensate

for this condition by increasing the viscosity of the lubricant to any great extent, as is often done on heavily-loaded bearings, for the penetrative ability of the lubricant would thereby be markedly decreased, especially in view of the small clearances involved.

It is evident that the lubricant must have sufficient fluidity to penetrate thoroughly the entire link, whether pins and bushings, rollers or rocker joints are involved.

On the other hand, to prevent external wear of the sprocket teeth and chain, a relatively heavy, adhesive lubricant should be used which will both resist any possible effects of centrifugal force, and stick to the wearing surfaces. Such a lubricant, being regarded as semi-solid, is naturally too viscous to serve the internal bearings. Hence, we must compromise and select a lubricant of sufficient viscosity to meet one purpose, with the retention of as much adhesion as possible.

Certain steam cylinder oils, or petroleum residuums, have been proven to be the best bases for such a lubricant. They can, when necessary, be blended to the desired viscosity with lighter, straight mineral products, dependent upon the experience of the operator.

Bending or articulation of a driving chain imposes wear not only on the link pin bearings, but also at the points of contact between the chain and the gear or sprocket. This is often regarded as the chief cause of external wear on both, even though correct chain design works toward the elimination of this tendency as far as possible, confining any necessary rubbing or rolling to the joints of the chain. As a result, a suitable lubricant should be capable of effectively serving both internal and external wearing points, at all times.

The duty imposed upon any such lubricant will, of course, become all the greater when chains must be operated in the presence of dust, dirt, water, or chemical fumes. In such cases it must serve as a lubricant, and as a protective agent for the bearing surfaces. Foreign matter such as grit, dust, acids, and moisture will tend to promote wear and corrosion to a marked extent.

Grit and dust are extremely penetrative; therefore, they will always tend to work into clearance spaces and immediately increase the wear. As a result, unless the lubricant is of the proper viscosity and base, it will often become incorporated with such foreign matter and develop an abrasive tendency that may ultimately lead to marked increase in power consumption and repair costs.

It has already been stated that a chain lubricant must penetrate to the rollers, rockers or sliding surfaces of the links, for it is evident that it will do no good to apply a lubricant to the surface of a chain if it has not the penetrative ability to reach the clearance between the wearing surfaces by virtue of its viscosity. Oftentimes too little attention is given to roller chains, due to their seemingly rough construction. This is shown by the use of waste oils that are carelessly applied at intermittent intervals.

Any such lubricant should be brushed uniformly over the wearing surfaces while they are operating slowly. Heating of heavier products will often be advisable in order to facilitate the spreading of a thin, even coating, and to insure proper penetration.

Silent chains, in turn, may operate exposed, or in an oil-tight casing. The speed of operation is oftentimes regarded as a guide as to the advisability of using a casing. In service where dust, grit, or other foreign matter is present a casing is always advisable whatever the speed; otherwise excessive contamination of the lubricant may occur. Any chain that operates in a dust-proof, oil-tight casing and is equipped with some form of automatic lubricator will require the least attention and operate most efficiently.

Splash lubrication, using a disc or collar attached to one side of the main shaft, is one way of bringing this about. As the wheel rotates the disc dips into the oil in the base and throws it to the top of the casing which is built in the shape of a wedge. In consequence, there is a continuous dripping of oil upon the chain. In casings of this type, the oil level is below the chain, the disc alone dipping into the oil.

There are other types of casings that depend upon bath lubrication. In these the oil level should be somewhat above the lowest part of the chain, for the latter acts as its own oil distributor. Where high-speed chains are involved, the casings are often equipped with an oil pump. Pressure lubrication is thereby obtained, the oil being sprayed continuously upon the chain links.

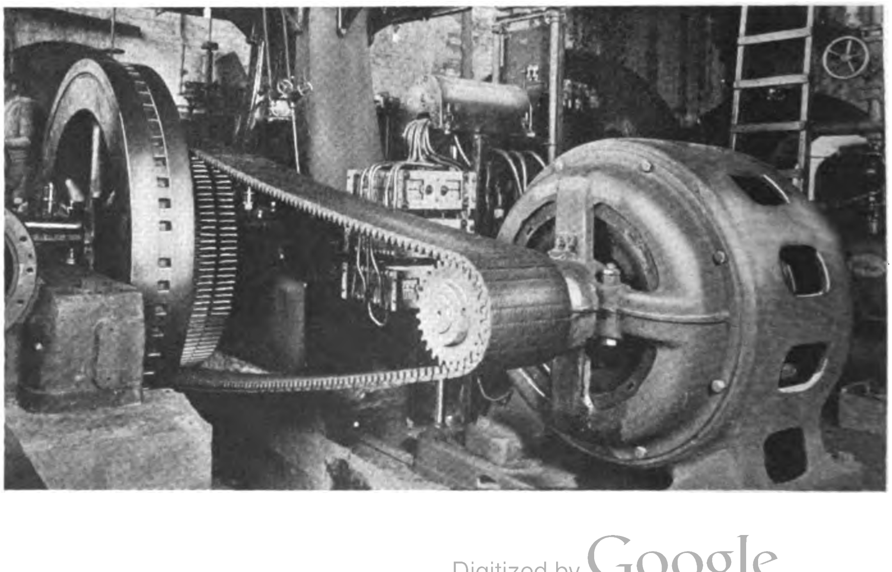
Where a silent chain is exposed or uncased, however, the lubricant must be applied either by brushing over the driving surface, or by removal of the entire chain for treatment, such as immersion in the lubricant.

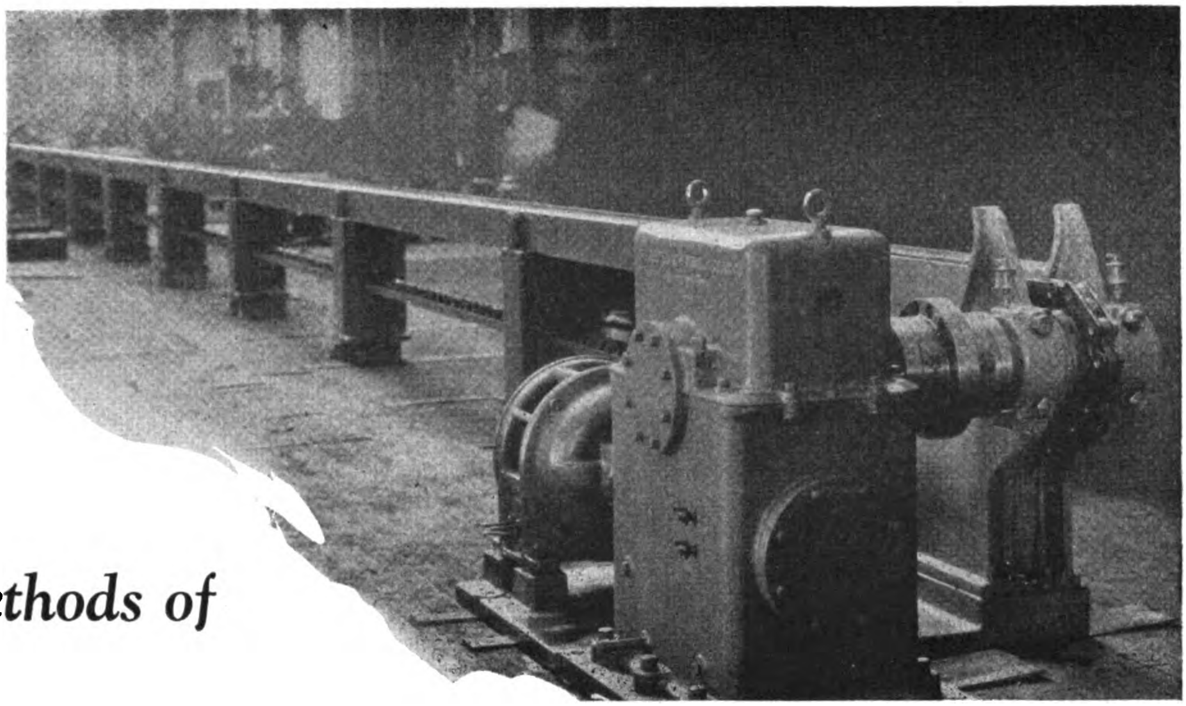
The necessary frequency of any such treatment will, of course, depend upon the type of chain, the speed, and the possibility of the lubricant becoming contaminated. Inasmuch as clearances in silent chains are usually very small, it is generally advisable to use a relatively fluid straight mineral oil for such treatment. When chains are encased, if they are to be bath-lubricated, a machine oil having a viscosity of from 500 to 700 sec. Saybolt at 100 deg. F. will be suitable. Where exposed, however, or encased but not immersed in oil, a heavier lubricant such as a mineral cylinder oil or light gear lubricant should be used.

Greases are also suitable for use on exposed chains, especially where there is sufficient clearance to enable proper penetration and retention of the lubricating film.

Fig. 6—An exposed silent chain drive requires care in the application of lubricant.

A light grease is frequently preferred so that it may be brushed onto the under side of the links from whence it works its way into the clearance spaces of the connecting elements.





Worm-gear drive on a 10,000-lb. drawbench. Shock and impact characteristics of the load impose severe operating conditions on this worm-gear unit.

Methods of handling Shock or Pulsating Loads

IN THE design of any power transmission system, either electrical or mechanical, shock loads constitute a very troublesome but important factor that must be given careful consideration. Whether shock is represented by the surges on a transmission line, the impulses of a reciprocating pump, the impact of rolling mill service, or the effect of inertia caused by the sudden starting and stopping of equipment, due allowance must be made for it, if reliability of service and freedom from high operating and maintenance costs are to be obtained.

In the mechanical transmission of power, shocks may take the form of large and sudden increases in load, at regular or irregular intervals, or they may be represented as smaller variations in load that occur rythmically, or on a definite time cycle. The term pulsating is frequently applied to the latter type of load.

When the load on any piece of equipment is comparatively uniform and constant the problems involved in designing the machine and laying out the drive are usually relatively simple. Stresses can be calculated with reasonable accuracy and with our present knowledge of the strength of materials it is not a difficult matter to design the various elements so as to allow as large a factor of safety as may be desired or dictated by good practice. When shock or pulsating loads are encountered, however, more complicated problems are presented. It is not always an easy matter to determine the magnitude of the shocks or impulses that the equipment will have to stand. Consequently, there is considerable room for the exercise of good judgment, based on previous experience in solving similar problems, in deciding how shocks may best be absorbed and how much excess capacity must be allowed in the equipment that is selected to do the work.

From the standpoint of the power transmission engineer the presence of a shock or pulsating load should indicate the necessity for a careful study of the operating requirements and conditions peculiar to each installation. It must also be borne in mind that in the case of machines whose power consumption fluctuates suddenly and widely the drive connection between the motor and the machine shaft should be considered with reference to the maximum load that is to be placed on it at any time, and not upon the average load to be transmitted.

On the other hand, when selecting a motor for a given drive, advantage should be taken of the fact that motors will stand considerable overloads for short periods of time. This characteristic will generally permit the selection of smaller motors than are usually applied. The usual tendency is to select a motor to fit the maximum demand placed on the machine, rather than one whose rating more nearly corresponds to the average load.

Successful transmission of power to machines that impose a shock load is not confined to any one type of drive. Direct connection of motor and machine through a flexible coupling, and belts, chains, and speed reducers have all been used with success when the application was properly worked out.

The following examples will serve to show how some interesting problems were solved in the transmission

of power when shock or pulsating loads were an important factor to be considered, and other operating conditions such as the necessity for maintaining short center distances and so on imposed limitations that made the problems more difficult to solve.

F. E. BARDROF, *The Cleveland Worm and Gear Co., Cleveland, Ohio.*—In the older plants devoted to the manufacture of seamless tubing products, all drawing benches were driven from one source, by means of a shaft that extended the entire depth of the plant, and perpendicular to the benches. As production increased and additional benches were added, the drive shaft was extended by coupling to the original shafting until the limits of room and the driving unit had been reached.

The driving unit originally consisted of a steam engine driving the main shaft through a train of gears, or by means of belts and lineshafting if two parallel main drive shafts were employed. In this system of group driving a large main motor eventually replaced the engine as a source of power.

With this change, however, the usual troubles existed as in the earlier type of drive. The main shaft furnished the power for each individual bench, necessitating continual service for one or all benches whether drawing tubing or not. The driving unit of the group-drive system had to carry the friction losses of the equipment under any schedule of production, as well as the enormous stresses from shock when under full production schedule.

One large manufacturer of seamless tubing, after installing the unit-drive system found it so satisfactory that additional orders have been placed for duplicate equipment. Each drawing bench, as shown in the illustration, on page 477, is a complete unit consisting of the bench and the drive equipment, which is located at the foot of the bench.

A 25-hp., 720-r.p.m. motor is used to drive the chain and carriage through a size 600 AT Cleveland worm-gear reduction unit with a speed reduction of 22.5:1. Connection to the bench drive shaft from the speed-reducing unit is made by means of a flexible coupling. With this type of drive, the principal advantages are compactness, flexibility, and low operating cost. It is evident, however, that this service is very severe on account of the shocks and impacts which it imposes on the drive.

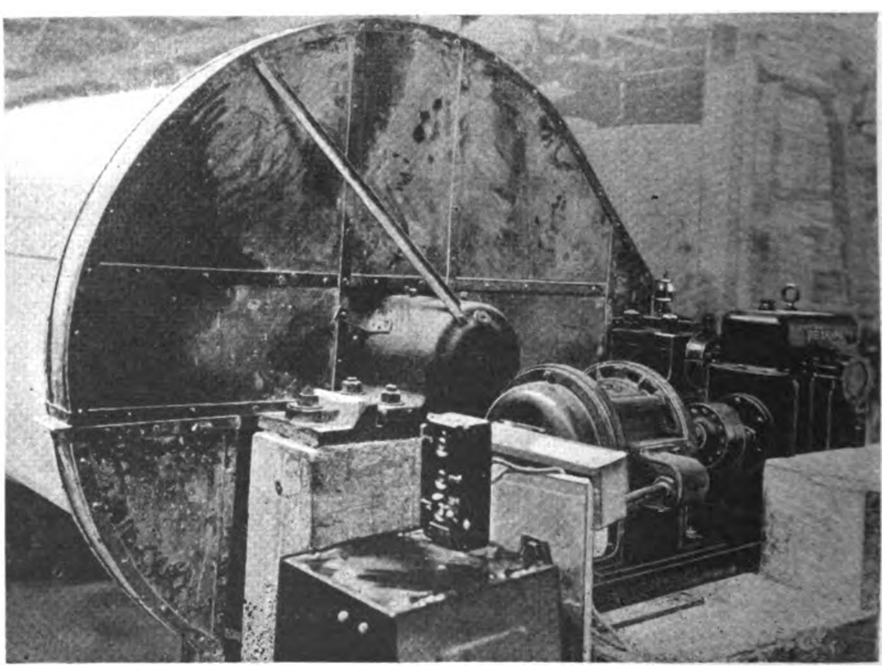
G. D. HERTZLER, *De Laval Steam Turbine Co., Trenton, N. J.*—In order to avoid a high-peak load due to the shock loads from the operation of grinding equipment, the pebble grinders in a flour mill are operated at night when the remainder of the plant is shut down.

Each pebble grinder is charged with its batch of material, and when a revolution counter indicates that it has run the exact number of revolutions to produce the proper consistency of the product, the grinder is shut down.

With the belt drive formerly used it was necessary to operate the 50-hp. motor until the last grinder was shut down, so that the motor was running a great part of the time with very light load and a correspondingly lower efficiency.

In operation these grinders impose a shock load of considerable magnitude on the driving equipment. After De Laval worm-reduction units and individual motor drive had been installed on each grinder, it was found that the required number of revolutions were reached more quickly due to the absence of belt slippage and also that there was a considerable saving of power. The grind is now completed in three and one-half nights instead of five, and four mills now do the work that formerly required six. Only one man is needed instead of two, and there is less maintenance. In addition, operating costs have been reduced one-third.

Other incidental advantages have been the elimination of oil drips from shafting and leather lint and dressing from the belts, which helps to keep the plant scrupulously clean; consequently spoilage is reduced. There is also greater uniformity of product.

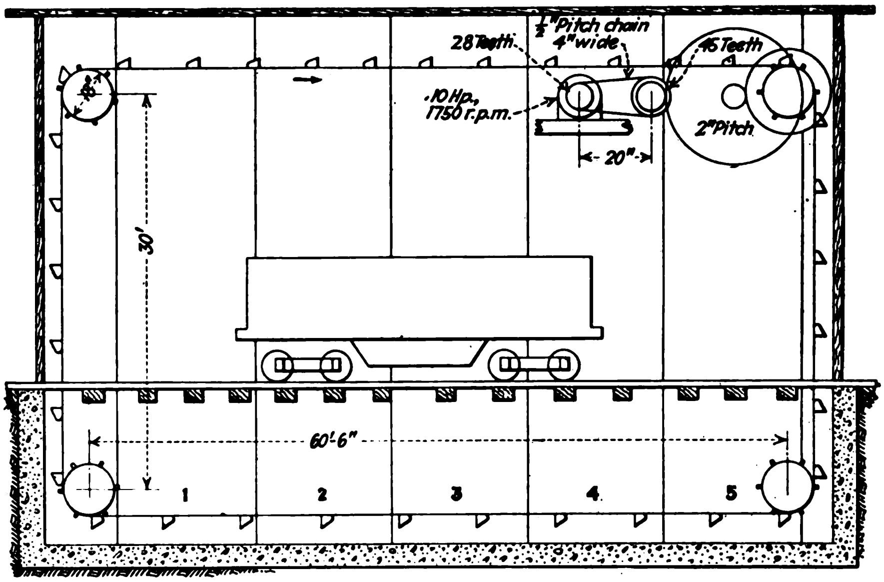


One of six pebble grinders that were formerly driven from line shafting and belts by a 50-hp. motor.

Severe service is encountered in this type of equipment due to the pulsating character of the load caused by the piling and rolling action of the pebbles with the charge.

DONALD A. HAMPSON, *Plant Superintendent, Morgans & Wilcox Mfg. Co., Middletown, N. Y.*—Solid steel disks on which the outlines of teeth were faintly discernible represented the remains of gears that been the driver and driven members of the first reduction in the train that drove the conveyor of a coal-handling system. These gears of five pitch, one having 30 teeth and the other 50, had been in service for only three months when they were stripped while several cars of coal were being unloaded. In order to meet the emergency, blanks for 10-in. gears were obtained, milled and delivered the day following receipt of the blanks. Three months later these gears failed.

Inasmuch as the original gears had a 2-in. face, we provided new gears with a 3-in. face so as to give increased wearing surface. Checking up on the load while waiting for these blanks to arrive, it was found that there was ample wearing surface even on the original gears. However, some three months later this set of



The drive connection between the motor and the main shaft of this coal-handling system is subjected to heavy shock loads.

After three sets of gears had failed following about three months' service each, a Morse chain was installed in place of them and has been in service for 13 years.

gears failed also, causing a shutdown.

As shown in the illustration, the coal is dumped underneath the track into a pocket which tapers off to a 2-ft. trough along which the conveyor system is driven by means of a 10-hp., 60-cycle, 1,750-r.p.m. repulsion motor through gear trains to the bucket sprocket wheels.

The buckets and chains traverse the bottom of the steel-lined pit and ascend 30 ft. to the upper level where the coal is delivered to the bin specified. The bins are indicated in the accompanying illustration by perpendicular lines, and numbered from left to right.

The gears in the first reduction necessarily operated at high speed and were pulling a severe pulsating load. In addition, they were frequently subjected to heavy shocks caused by choking of the conveyor with coal as the cars were dumped.

After three similar failures, something had to be done; so after a study of the problem we decided to install a silent chain drive. Accordingly, a ½-in. pitch Morse chain 4 in. wide with two guide links and two sprockets, one having 28 and the other 45 teeth were obtained and installed as shown in the illustration on this page.

A recent inspection of this drive after 13 yr. of service leads us to believe that it is in condition to render as many more years of reliable service under the same operating conditions.

These conditions are really very severe. In addition to the hard service imposed by the character of the load the drive is located close to the roof where it receives very little attention and is exposed to a large amount of coal dust, without any protection.

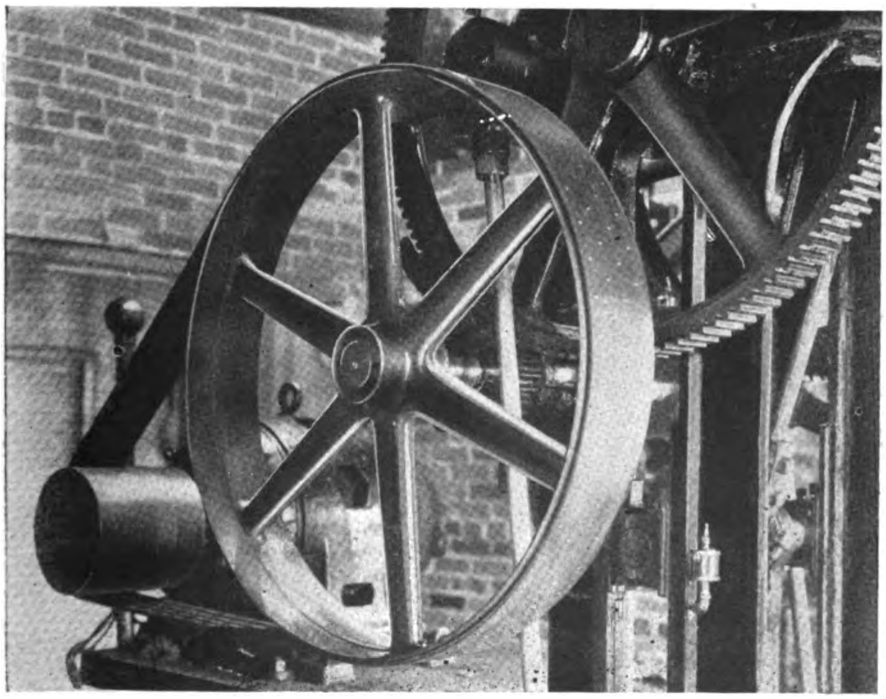
J. L. De RABOT, *Consulting Engineer, Alexander Brothers, Inc., Philadelphia, Pa.*—A drive that gave considerable trouble was encountered on a deep-well pump installation where the shock of the pulsating load from the reciprocating action of the plungers was transmitted to the drive connection between the motor and the first reduction element of the pump.

Due to the space available for the equipment, the distance between centers of the first reduction was unusually small. A 10-hp., 860-r.p.m. motor having a 10-in. pulley, drives a 36-in. pulley on the pump at a center distance of only 30 in.; so the very small arc of contact on the motor pulley is obvious.

Under identical conditions of operation, gears had been used in this first reduction element, but after several failures due to the nature of the load and perhaps careless operation, they were replaced with a chain drive which ultimately fared no better than the gear installation.

On account of the short center distance of the drive as it was installed, little consideration was given to the use of belting, because in addition to the small arc of contact on the motor pulley, the belt would have to pull from the top side. However, under the assumption that the pulsating load was responsible for the failures of the previous drives, in that the connection was unable to absorb the shocks, the 5-in. Tentacular belt shown in the illustration at the left was recommended and installed.

Despite the unusually severe service that this installation imposes no trouble has been experienced from excessive slip or wear. The equipment is available for full capacity operation at any time.



The belt driving this deep-well pump carries a pulsating load while operating on short center distance.

Gears and chains had been used previously on this 30-in. pulley center drive, but failed to stand up. This is a tentacular belt.

R. C. MOORE, *Warren Belting Co., Worcester, Mass.*—Considerable difficulty was experienced in keeping a Curtis compressor at the Syracuse plant of the Dunning & Boschert Press Co. running, due to frequent belt failures.

Following a period of exasperating delays, the management requested us to make an analysis of the problem and submit our recommendations in order to arrive at some conclusion as to whether the compressor or the drive should be replaced because they were obliged to keep three belts on hand all the time. One belt would break and while it was being repaired, a second belt would sometimes break necessitating the use of the third reserve belt. As many as four belts were replaced in one year.

Knowing the type of installation and the rapidly changing loads to which any belt drive here would be subjected, our recommendations were for an 8-in. Wabeco double belt which was installed May 5, 1924. Since that time, it has been in constant service without layoff except at night and is still in good condition.

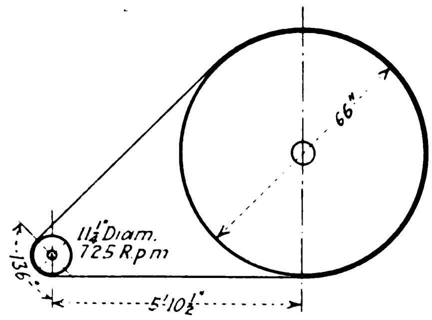
J. EDGAR RHOADS, *J. E. Rhoads & Sons, Philadelphia, Pa.*—One of the most severe shock loads that we have had to handle was encountered on the drive for a three-stage compressor in which the pressure was built up from a low figure to over 2,000 lb. per sq.in. in a very short time.

The drive consists of a 40-hp., 725-r.p.m. motor with an 11¼-in. pulley driving to a 66-in. pulley on the compressor with an 11-in. leather belt through a center distance of 70½ in. The speed of the compressor was, therefore, approximately 128 r.p.m.

An idler was formerly used on this drive to increase the arc of contact on the motor pulley, but a 3 per cent slip persisted when operating under the heaviest pressure. This drive was considered an extremely difficult one for this reason. Because of this condition the compressor was never able to attain its rated capacity. The pulsating nature of the load with what was thought to be the best belt in use prevented a reduction in slip which restricted the maximum output.

On the basis of service requirements for this type of drive a heavy double Tannate belt 11 in. wide was installed and run without employing an idler.

Even with the reduced arc of contact this belt is running with approximately 1 per cent slip, and the compressor is operating at its full rated capacity under maximum pressure in less time than was previously found possible. As shown in the illustration, the arc of contact is only 136 deg.



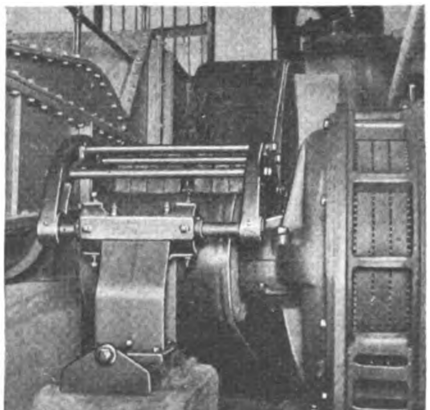
The arc of contact on the small pulley of this compressor drive is 136 deg.

Practically no attention has been given this belt which has been in service for many months, but repeated tests on it have confirmed the low percentage of slip.

STANLEY HASTE, *The Bird Machine Co., South Walpole, Mass.*—Drive equipment for the operation of breaker beaters must be of a substantial nature to withstand the shocks and variations in load to which they are usually subjected.

In a jute plant, such a drive having a 100-hp. motor on it contributed its share of interruptions to production by belt slippage and consequent burning that necessitated frequent renewals of the belts.

Lack of space around the machines prevented the adoption of any other type of drive and the width of the pulleys used restricted the use of belting material other than leather. Short center distance between the pulleys was also a factor for the continuance of belt drive; so in finding a way out, it was decided to use an idler.



The drive on this breaker beater is subjected to severe shocks and variations in load.

Excessive belt slippage and other trouble led to the installation of a Pulmax drive, which has eliminated the former operating troubles.

A Pulmax unit was installed as shown in the illustration at the bottom of the preceding column. A second-hand belt was put on the drive and after years of service is still in good condition.

The difficulties encountered prior to its installation have been entirely eliminated, for with sufficient capacity in the motor and belt for the maximum load in the beater, there is maximum contact area on the motor pulley to counteract any shocks transmitted by the charge.

With this arrangement instead of the shocks and load variations being absorbed by the belt, through slippage, they are now spread over and smoothed out by every element of the drive, including the distribution system.

Eliminating Belt Slippage on Coal Breaker Drive

BELT slippage is not only objectionable from an operating standpoint, but when severe it is injurious to the belt. In one instance that came to my attention, a good deal of trouble was experienced with a belt drive on a coal breaker. The 500-hp., 560-r.p.m. motor that drives this breaker has to start up under nearly full load. As a result, the belt frequently slipped off during the starting period, causing considerable annoyance and delay in production.

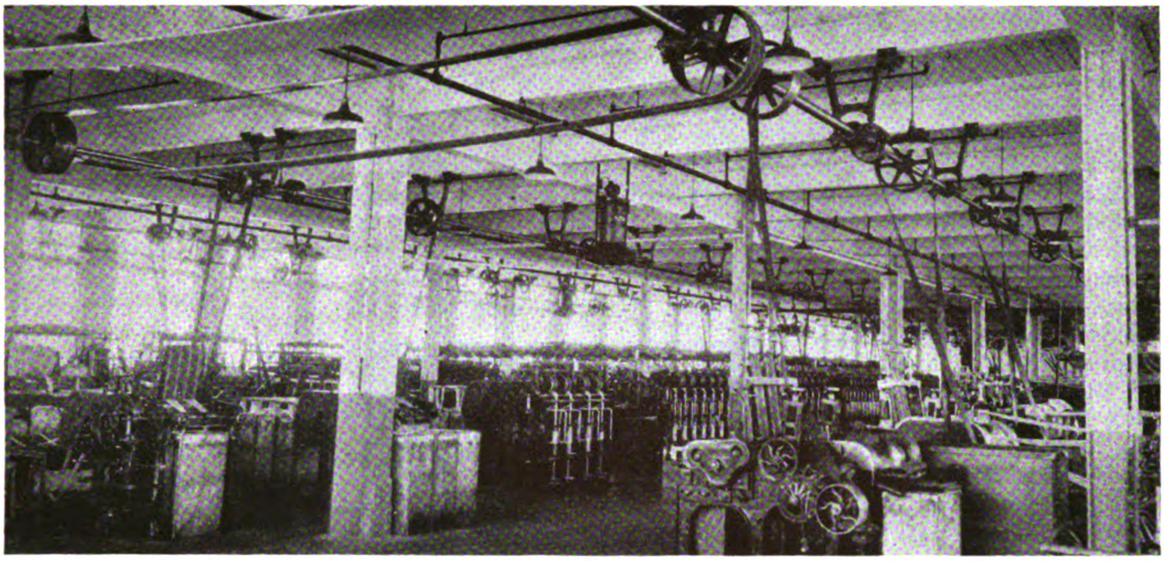
The motor is started from a central control room and time was naturally wasted in notifying the operator to stop the motor, when the belt came off. Even when the belt did not run off there was enough slippage to create a very undesirable operating condition.

Various methods of holding the belt in place were tried, but none of them was successful. Eventually one of our engineers was called into consultation and recommended the use of an American, cork-insert, split steel pulley. This pulley is a special, heavy-duty type 44.5 in. in diameter and 38 in. wide.

A 9-ply endless rubber belt 36 in. wide is used on the drive, and since the pulley was installed several years ago no further trouble has been experienced from the belt slipping or coming off the pulley.

D. W. PEDRICK.

The American Pulley Co., Philadelphia, Pa.



A view of one department in a Maine textile mill that contains about 1 mile of lineshaft supported by SKF self-aligning, ball-bearing hangers.

Bearing Troubles

How they have been solved

FOR many years the ordinary or sleeve type of bearing was used exclusively in all kinds of machines, and served its purpose well. Fifty years ago, say, the demands made on bearings were much less severe than they are today. Loads were in general less heavy and speeds much lower. Again, power losses through friction were not given the careful consideration they receive today. In short, the disadvantages of sleeve bearings were regarded as inevitable.

The development of modern high-speed and high-capacity production and power transmission equipment brought new requirements and new standards of bearing performance. There came likewise a clearer realization of the exceedingly important part played by bearings in the transmission and utilization of mechanical power. Various designs of anti-friction bearings were accordingly brought out in response to the obvious need for a bearing that possessed all of the good qualities of sleeve bearings and as few of their disadvantages as possible.

Out of the vast amount of research and development work that has been done on anti-friction bearings there have come two general types—the ball and the roller bearing.

Coincident with the development and application of anti-friction bearings, a good deal has been done to improve the sleeve bearing. Much of this work has been along the line of developing better bearing alloys and improving the method of lubrication, although one large manufacturer has designed a so-called sealed sleeve bearing for use on motors that has been very successful.

Much has been claimed for anti-friction bearings and in many installations their performance has justified these claims. Assuming that they have been properly applied, anti-friction bearings can usually be counted upon to give trouble-free service. Application of a suitable lubricant a few times a year is about the only attention required, whereas most sleeve bearings have to be lubricated weekly or oftener. Generally a saving in power can be made by the use of anti-friction bearings. One of the decided advantages over sleeve bearings is the fact that the starting friction is much less than that of the other type. This means that less power is required to start heavy loads and bring them up to operating speed. At usual operating speeds the running friction of good sleeve bearings is, however, much nearer to that of the anti-friction type than is sometimes realized.

Anti-friction bearings have solved many difficult problems and have demonstrated their value extensively.

Operating men are confronted with the problem of determining just where these fields lie in their plants. Using as a basis of comparison the average performance of sleeve bearings, such questions as, Under what conditions will the savings that anti-friction bearings can make justify their use? What part have they played in solving operating problems? What operating advantages do they offer? and so on, are interesting and important.

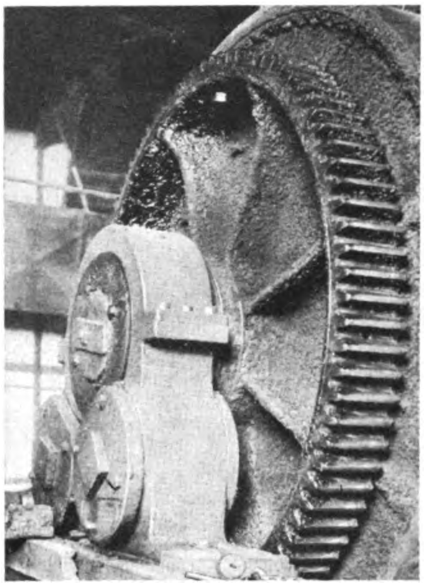
To these questions general answers based on the results obtained in service are given in the following pages.

A. K. WEST, *The Timken Roller Bearing Co., Canton, Ohio.*—An application of anti-friction bearings that possesses considerable interest, not only because of the operating improvements effected but because of the mechanical difficulties overcome was made to the trunnions of a mill or tumbling barrel used to powder enamel. The mill consists of a barrel, or drum, about 8 ft. in diameter and about twice as long, which is driven by a 25-hp. motor from a lineshaft. When filled it forms a load of about 10,000 lb. on the trunnions. The conditions under which it works call for what amounts to 24 hr. operation, seven days a week, since each batch requires a 36-hr. run, and the batches succeed each other as fast as one can be taken out and the other put in.

Before going into the results obtained by the bearings, a description of the method of applying them may be of interest. There are four stub trunnion shafts, two at each end. Each shaft is mounted on two Timken bearings, arranged indirectly, that is, having the apex of the angles of taper in the center of the shaft between the cones. The cups are pressed into the opposite ends of a retaining ring, or sleeve, and are located by shoulders machined in the ring. At this point there is a slight difference in the arrangement on the two ends of the drum shaft. On the gear end, a collar is shrunk around the drum shaft on which there is a tongue, that engages a slot cut into the outer surface of the bearing retaining ring. The purpose of this guide collar, as it is called, is to locate the shaft with respect to the trunnion bearing assembly. On the other end of the drum shaft the guide collar is omitted.

Before tapered roller bearings were adopted on this machine, considerable bearing trouble was experienced, due principally to the load characteristics of the machine itself. In machines of this sort, there is always a tendency for the whole mass of material in the interior to climb part way up one side, and then fall to the bottom against the direction of rotation. The consequence is that a heavy fluctuating load is placed on the bearings, and unless they are designed to withstand it, it may cause trouble.

At first plain sleeve bearings were used in the trunnions, and the effect of the condition just described was that the bearings had to be renewed about every six months. The next thing tried was a straight roller bearing, built by the owners of the machine, and, although these were an improvement, a good deal of trouble was still experienced. The effect of the shifting load was such that ridges were soon worn in the lower surface of the outer bearing race, which caused uneven wear and other troubles with the rollers. A remedy which was adopted for this condition consisted in turning the bearings on the shaft periodically, so as to bring a fresh surface under the rollers at the point where the wear occurred. However, even this was not very satisfactory because of the delay and labor involved.



Close-up view of Timken-equipped trunnions on an enamel-pulverizing mill.
In machines of this type, the tendency is for the charge to climb part way up one side and fall to the bottom against the direction of rotation. A heavy fluctuating load is thus placed on the bearings, and greatly increases the severity of the service.

Timken bearings were installed well over a year ago and, in spite of the fact that the machine is operated continuously, there has never been any delay, or other trouble caused by the bearings. In addition, the friction load formed by the machine has been materially reduced, which has resulted in a saving in the power required to drive it. The actual amount of power saved is not known, because other equipment is driven from the same lineshaft, but it is estimated at between 15 and 20 per cent.

As an indication of the reduction in friction that has been effected, the following feature is illuminating. Before the machine was equipped with its present bearings it was necessary when starting it up loaded to rock it through an arc of about 90 deg. several times before applying the power. Now it can be started from a standstill when loaded, without putting any undue strain on either the motor or the power transmission equipment.

H. E. STAFFORD, *Electrical Engineer, Provincial Paper Mills, Ltd., Port Arthur, Ont., Can.*—In our power plant we generate over 2,000 boiler horsepower, mine run coal being fed to the boilers by mechanical stokers. The coal-handling equipment consists of a crusher, an elevator leg, and a belt conveyor driven by motors which were installed in 1923.

For some time, considerable trouble was experienced with the lubrication of the crusher motor, which was equipped with sleeve bearings and open endbells. As the crusher is belt driven, a considerable amount of coal dust was carried on the belt to the motor, although it was protected by a curtain.

In order to overcome the bearing troubles, new endbells were cast, with provision for mounting ball bearings in them. The endbell at the pulley end was blanked so that the motor is totally inclosed on that end, and the opposite endbell was provided with small openings for ventilation.

Before changing the motors to ball bearings, it was a common occurrence to change at least one bearing every two weeks, whereas since the change was made no more bearing troubles have occurred.

A. A. McGOWAN, *Marlin-Rockwell Corp. (Gurney Division) Jamestown, N. Y.*—In these days of high-speed equipment and of mass production, manufacturers are continually on the lookout for ways and means of improving their product. Ball-bearing applications are doing their part in helping the manufacture to get the utmost from his product, and in many cases at very little additional expense.

A typical example of this came up some time ago. A well-known manufacturer of high-grade, rubber-working machinery had just placed on the market a high-speed tuber that was not giving the results expected from it. The output was exceedingly low when compared with the power consumption.

The principle of operation of this machine is similar to that of the ordinary kitchen meat grinder. The hot, gummy stock to be cleaned or refined is fed into the machine, and forced through a strainer at the out-

put end. When used as a tuber, a die is used in place of the strainer and a continuous seamless rubber tube results.

A tremendous thrust load is built up by the stock screw in forcing this mass of gummy rubber through the strainer or the tubing die. In the original application, a large, marine thrust bearing was used. Bearing failures were frequent and while these machines were being repaired, production was stopped and a double loss ensued. Maintainance costs became a bone of contention.

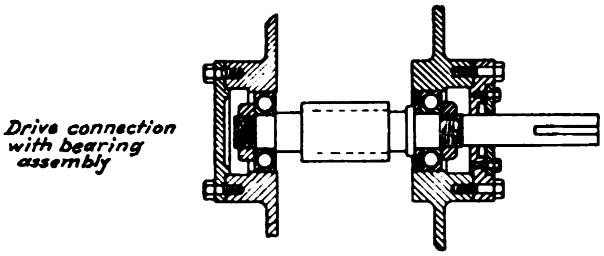
Lubrication was still another problem. The heat that developed from the tremendous worm thrust would raise the temperature of the oil to the boiling point after a period of operation. This necessitated an elaborate cooling system for reducing the temperature of the lubricant. The babbitt bearing would wear and the stock screw would get out of alignment with respect to its shell. As the bearing wore, the oil seal became less effective and lubricant began leaking out of the housing into the stock.

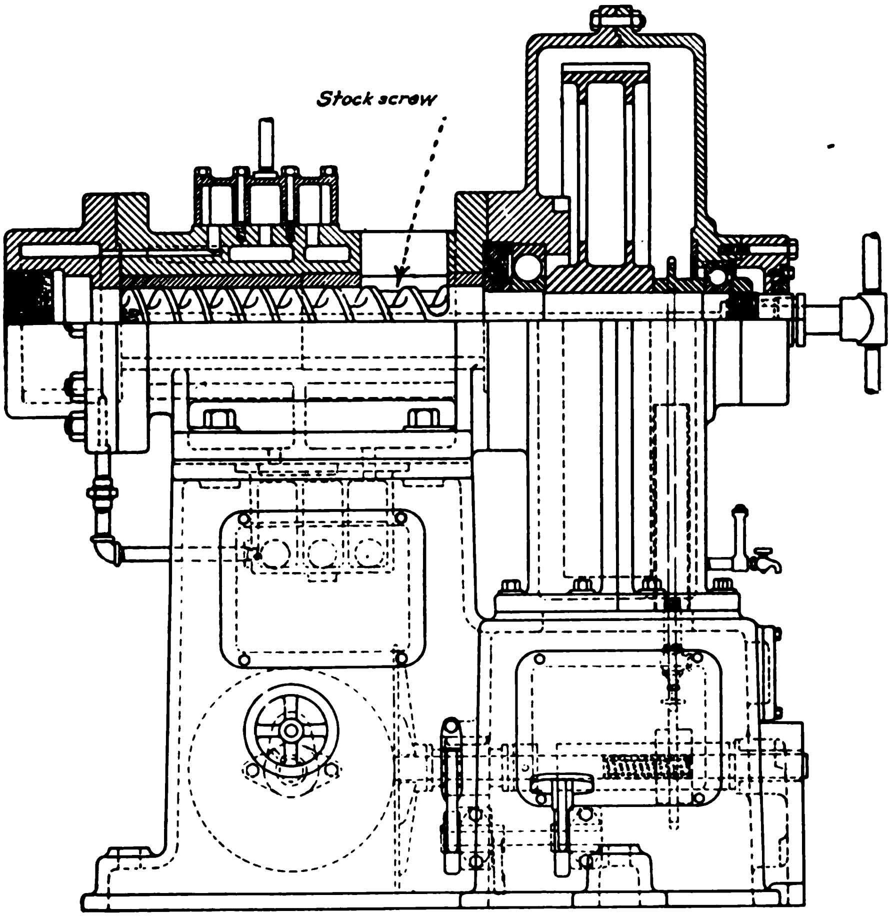
One of our engineers was sent to study the application and to co-operate in the development of a new design. Loads were calculated, and as a result the proper type and size of bearings were selected and layouts made of the housing and of the mounting arrangement.

The manufacturer set up a sample machine and put it under test. A distinct saving in power was noted. With this new arrangement it was also found that the very small radial play of the ball bearing held the stock screw so accurately centered, that a more uniform product was obtained. Oil leakage was reduced to a minimum with a consequent improvement in the quality of the stock. This improvement in performance is reflected in the results obtained on three different types of tubers.

Cross-section view of rubber tubing machine equipped with ball bearings.

The view at the upper right shows the pinion drive shaft with its complement of Gurney ball bearings and the housing arrangements. In the lower view the bearing assembly is shown in connection with the stock screw, which builds up a thrust load when forcing the gummy stock through the tubing die.





A 25-hp. tuber equipped with babbitted bearings throughout produced 1,500 lb. of stock per hour. An 85-hp. tuber equipped with a ball thrust bearing and babbitted radials produced 3,000 lb. of stock per hour. A 75-hp. tuber completely equipped with Gurney radial-thrust and radial bearings produced 6,000 lb. of stock per hour.

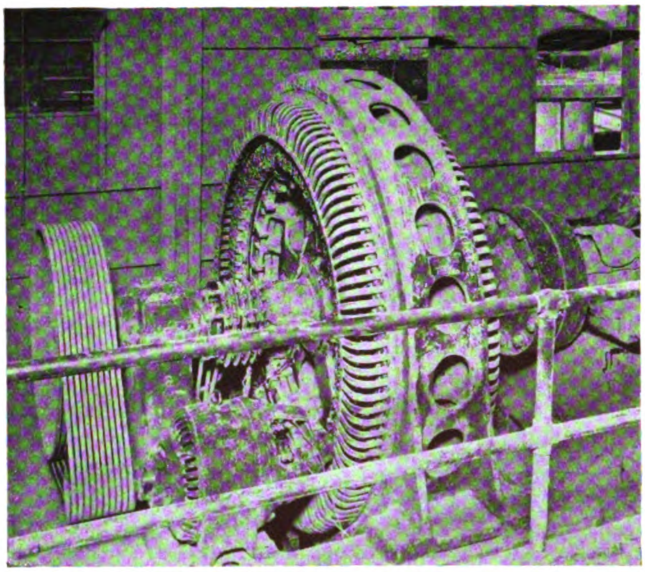
It is seen that there is a distinct difference in the relation of the horsepower transmitted to the pound output of the stock. The 75-hp. machine completely equipped with ball bearings produced double the output of the 85-hp. tuber and with less power, thus proving that the use of ball bearings converted the power lost in friction and boiling oil into useful work.

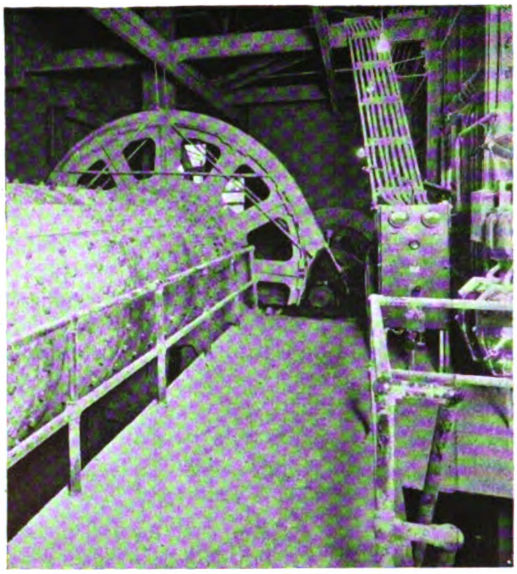
It is also of interest to know that a test was made of a peculiar stock that could not be put through the 75-hp. machine. The resistance was sufficient to stall the motor, but even under these extreme conditions there was no ill effect on either the machine proper or the ball bearings.

H. R. REYNOLDS, *Chief Engineer, The Fafnir Bearing Co., New Britain, Conn.*—A large manufacturer of canvas belting and fabric brake lining found that his loom-drive pulleys cost him more to maintain than any other unit in his production line, because a force of tool makers was continually at work rebushing these pulleys, and repairing and replacing the clutch yoke brasses.

This loom drive was perhaps poorly designed in the first place; nevertheless a ball bearing replacement was the simplest way to cure the conditions and, strange as it seems, the work the ball bearings had to do here was almost nothing. This particular pulley application was a clutch of very simple design. It was simply a large-diameter pulley with a flange face, leather lined on one side with a clutch yoke and the necessary shifter arms on the other. To start the machine the shifter, through the yoke connection to the pulley, moved the

(Please turn to page 489)





This 900-hp., 180-r.p.m., synchronous motor and the 8-ft.x35-ft. dry ballpeb mill for raw grinding, which it drives, are the largest units in the plant.

Methods of solving Power Drive Problems *in a cement mill*

By A. C. BROWN
Plant Manager
Kosmos Portland Cement Co.,
Kosmosdale, Ky.

FEW, if any, industries operate equipment under conditions worse than, or even nearly so bad as, those found in the modern cement plant. The severe operating conditions, such as dusty, abrasive atmosphere, high temperature, irregular and shock loads, heavy bearing pressures, and continuous operation, are particularly severe upon the equipment used to transmit power to the cement machinery or auxiliary equipment, such as conveyors, and so on, required in the production process. Luckily, most of the equipment is operated at comparatively low speeds which decreases to a certain extent the operating difficulties.

In the earlier days of the cement industry the short life of the equipment, bearings particularly, was considered as a necessary part and result of operation, and an allowance was made in production schedules for the expected interruptions. This necessitated the provision of extra equipment so that part of it could be down undergoing repairs, without interfering with production. Of course, some extra equipment must still be provided, but with the decrease in the amount of interruptions this extra equipment can be placed in regular production and so increase the output of the plant. Idle equipment, or machines waiting for maintenance, does not make cement and consequently is an extra expense.

The plant at Kosmosdale consists of a complete cement mill rated at 3,000 bbl. capacity per day with six kilns, two kilns $8\frac{1}{2}$ x 125 ft. and four kilns 7 x 6 x 80 ft. and all the necessary grinding and pulverizing mills, conveyors, storage bins, sacking and handling machinery, coal storage and pulverizing equipment. The kilns operate continuously and the rest of the plant is on a 24-hr., six-day schedule, which gives about three times the operating service ordinarily found in industrial plants.

A quarry, coal mine, and fleet of river barges are operated in conjunction with the cement mill, but will not be included in this discussion. The product consists of Portland cement and masons' plaster manufactured by the dry process.

This plant has been in operation about 23 years. Maintenance consists largely of attention to and renewal of bearings, and other metallic surfaces in sliding or rolling contact, and the renewal of interior parts of the equipment exposed to the abrasive action of the materials in process. Maintenance of production equipment is a distinct and separate subject and will not be discussed here. This article will take up the operation and maintenance problems incidental to the drives on the equipment.

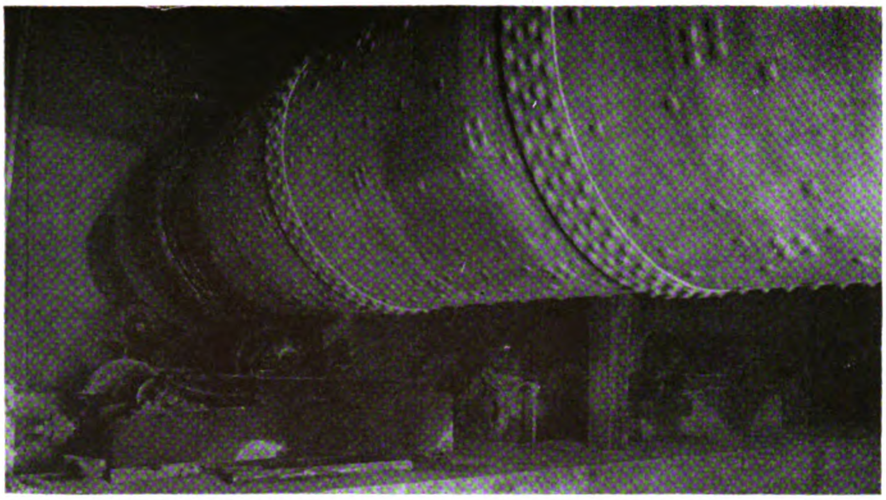
A large proportion of all bearing trouble results from inadequate or improper lubrication. The conditions around a cement mill are such as to make lubrication more difficult and at the same time much more necessary than in most industries.

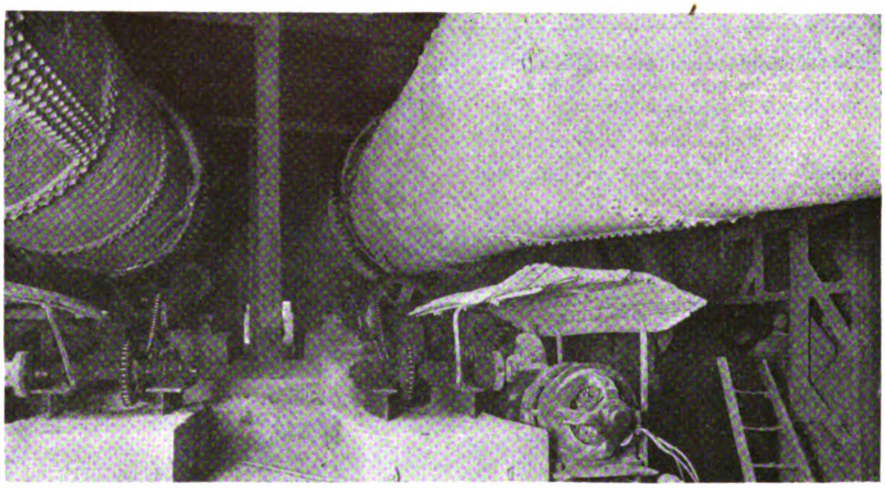
When the plant was built plain bearings were installed, as was the practice in the industry at that time. Because of the heavy abrasive atmosphere surrounding these drives few of the bearings would last more than two or three months. As the bearings wore the difficulty of lubricating them increased because of the greater space between the bearing and the shaft, which admitted more abrasive material and made the retention of oil impossible.

The only practical method of preventing this wear was to supply lubricant to wash the abrasive dust away and prevent it from remaining in the bearing. Badly worn bearings re-

This shows the types of drives used on the driers and kilns.

In addition to the dust and heat, the drives on the driers (top view) are subjected to severe shock load, due to the rolling and sliding of the material. Both driers and kilns are driven by motors through worm gear reducers, chains and gears. The drives on this battery of driers are being rebuilt to incorporate an improved type of worm reducer, Timken bearings, and to simplify the drive. The canopy over the kiln drive (below) protects the motor and drive from the direct heat of the kiln and also from falling particles. Lubrication is a difficult problem because of the heat, dust, and heavy bearing pressures.





quired an excessive amount of lubricant to obtain even a short bearing life. Carelessness in application was responsible for a large wastage of lubricant. In addition, shafts became badly worn at the bearings and either had to be shifted so that another spot came in the bearings or be renewed.

As an experiment a Dodge-Timken tapered roller bearing pillow-block was installed on a $3\frac{7}{16}$-in. shaft connected to a worm gear speed reducer driving an elevator head. Previously, an ordinary bearing seldom lasted three months on this work. Elevator head shafts are, as a rule, located in out-of-way places and are more or less neglected. This results in the shaft becoming out of line and causes excessive wear on chains and sprockets. This roller bearing has been operating for two years, without repairs of any kind. This is equivalent to between six to ten times the life of plain babbitt bearings under ordinary operating conditions.

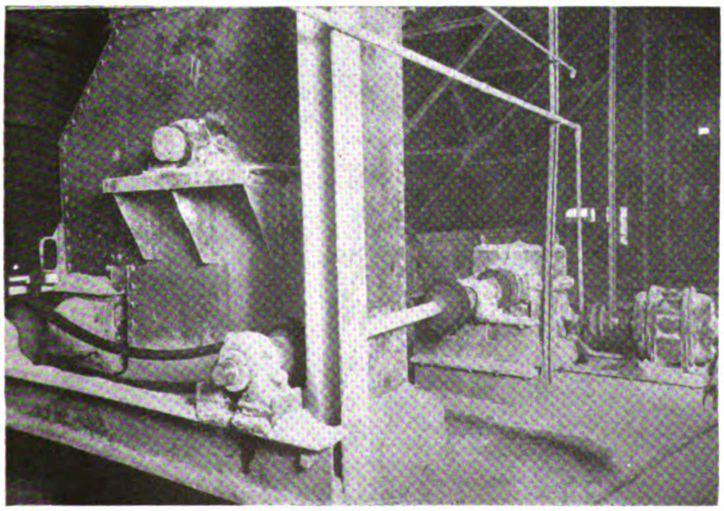
After this bearing had been installed 12 months it was opened and thoroughly inspected for signs of wear. The results were so satisfactory that about 30 per cent of the bearings in the plant are now equipped with Timken tapered roller bearings or Fafnir ball bearings.

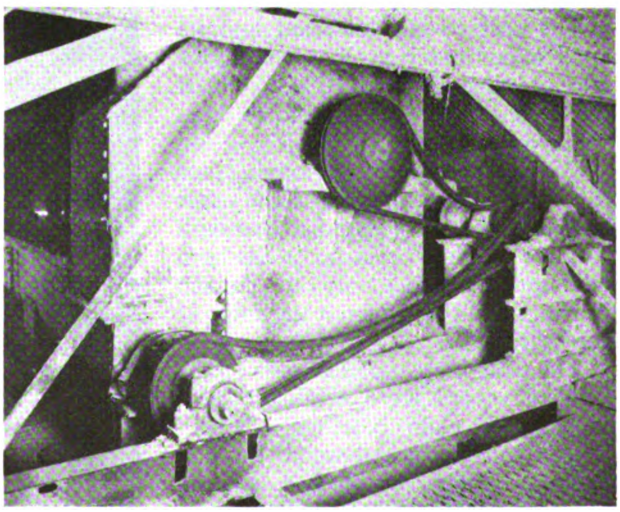
All elevator headshaft bearings and the bearings at the driving end of the screw conveyors have been replaced with tapered roller bearings. Plain bearings are still used at the discharge end of the screw conveyors where they do not receive such severe service as at the driving end.

Another place where roller bearings have been very effectively applied is on a $2\frac{15}{16}$-in. lineshaft, 70 ft. long driving mixing valves. This shaft is supported by nine Dodge-Timken pillow-block bearings and drives the valves through Diamond roller chains. These bearings have

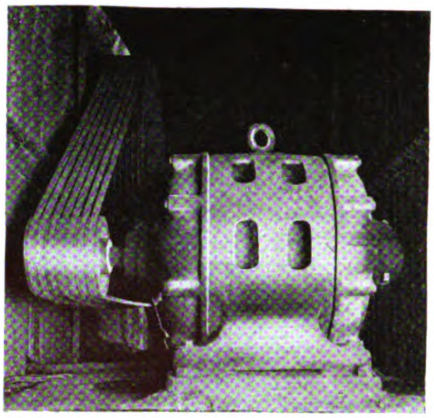
Two of the elevator and screw conveyor drives.

Each of the elevators and its screw conveyor must operate together; consequently the two are driven by a single motor through a Jones worm screw reducer which is connected through a flexible coupling to a $2\frac{15}{16}$-in. lineshaft mounted on Dodge-Timken pillow-blocks. The screw and elevator headshafts are connected by Diamond roller chains and are also mounted on Dodge-Timken roller bearings. Roller bearings have been in operation for more than a year in this kind of service, whereas the old, plain bearings seldom lasted three months.





been operated without any trouble for the equivalent of four years of ordinary operation. Before the roller bearings were installed, plain bearings on this one shaft lasted only a few months; then the babbitt had to be renewed and fitted to the worn shaft or the shaft replaced. The plain bearings required about 10 gal. of oil per month, and received attention several times a day. Much of this oil was wasted, of course, because a plain bearing must be flooded to flush out the abrasive dust and, in addition, a considerable amount of oil is simply spilled or misses the bearing. The roller bearings and also the ball bearings are lubricated once a month with grease of light consistency through Alemite fittings.

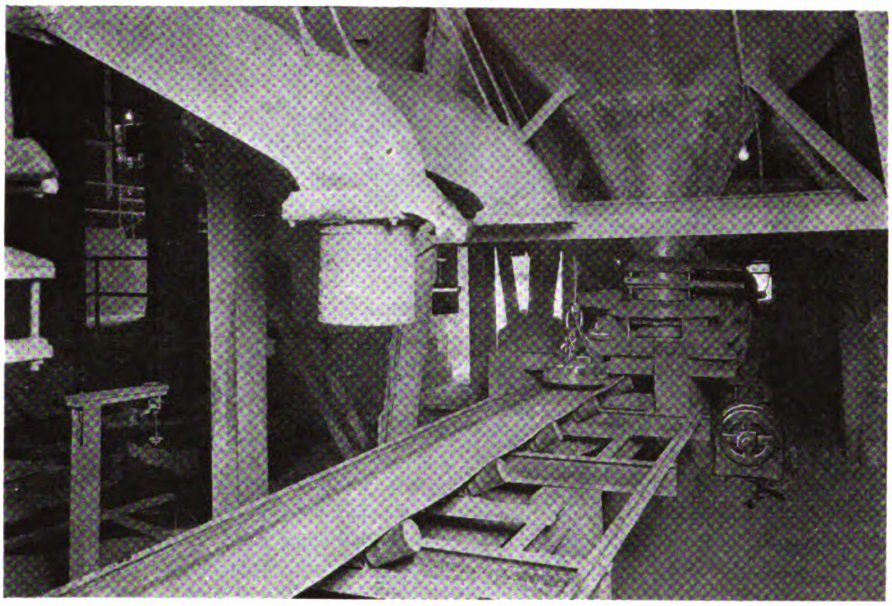


An unusual drive on a cooler.
In spite of the intense heat, a Texrope drive has been in service on this cooler for almost a year without taking up.

The cost of the lubricant and its application under present conditions is approximately only 10 per cent of the former cost for the same line-shaft drive.

We are considering equipping our tube mills and a number of the other comparatively slow-speed drives with Timken bearings. So far it has been necessary to replace only one Timken bearing, and that was not the fault of the bearing.

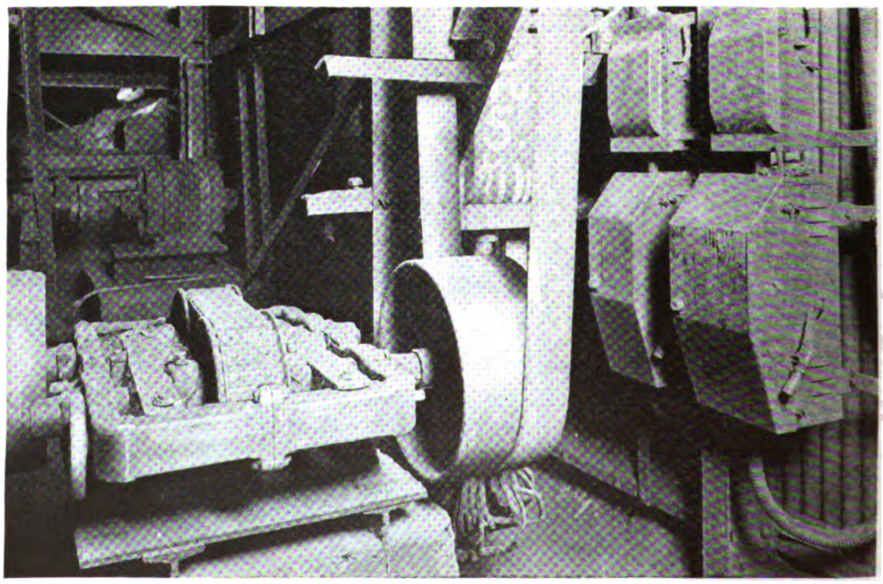
The troughing and idler rolls on the belt conveyors were originally provided with plain bearings. Whenever a roll sticks and wears through from the sliding of the belt it is replaced with a Link-Belt idler with Timken bearings provided with Alemite fittings for lubrication. Some of the conveyors have been changed over completely; altogether about 85 per cent of all the rollers have been changed to date. In addition, Dodge-Timken pillow-blocks have also replaced the plain bearings on the pulley shafts of the belt conveyors.



Motors and worm gear reducers are used on the belt conveyor drives.
Whenever a conveyor idler-roll sticks, it is replaced with a Link-Belt idler roll with Timken roller bearings fitted for Alemite lubrication. The driving pulley is also provided with tapered roller bearing pillow-blocks.

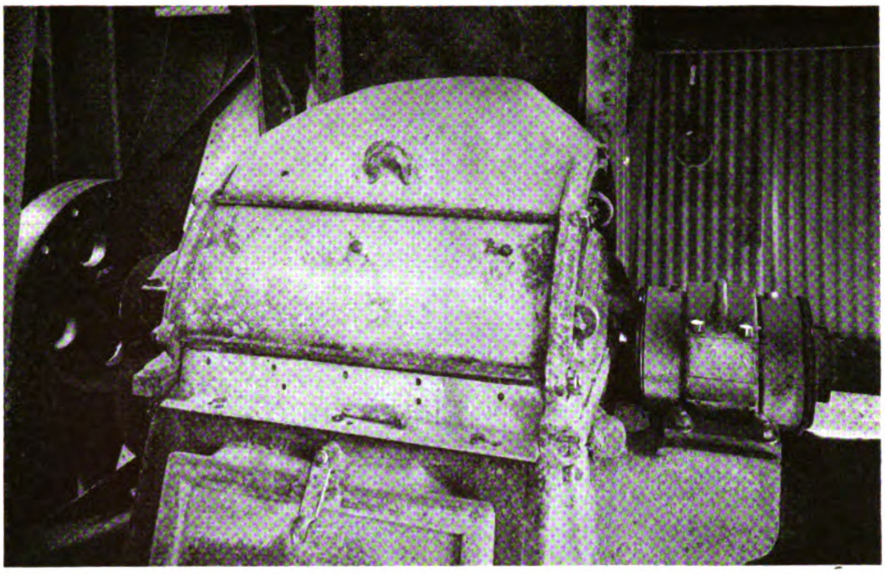
As stated before, a comparatively small amount of equipment in a cement mill is operated at high speed. For such bearings, however, we have adopted Fafnir ball bearings. One of the first ball bearing installations was on the fans used to supply air to the kilns. These bearings were installed in 1923 and have operated continuously during this time, without any repairs being necessary to fans or bearings. Previous to their installation the kilns were down quite often on account of fan bearing trouble.

We have also equipped the six economizer fans with ball bearings. These fans were equipped with water-cooled bearings on account of heat from the gases which the fans handle. These water-cooled bearings were a source of annoyance and had to be replaced quite often by reason of water lines becoming broken or choked up. These fans are of the overhanging type supported on two bearings. The fans are of large diameter and run at slow speed operating at 220 to 300 r.p.m., and are driven by the same motor that drives the kilns. Our idea in doing this was to increase the draft when the speed of the kiln was increased in order to take care of the larger volume of gases from the kiln, and also to reduce the draft on the kilns when the heat has to be in-



One of the variable-speed drives.
Six Reeves variable-speed transmission units are used on the coal feeder to the kilns. The Allen-Bradley across-the-line starting equipment is mounted on the wall at the right.

On high-speed operations, ball bearings are used.
This Williams pulverizer is mounted on $4\frac{7}{16}$-in. Fafnir double pillow-blocks, with extra dust shields. The dust, shock, and vibration from this drive impose very severe service on the bearings.



creased. These ball bearings have been in operation for three years with the same satisfactory results.

One of the accompanying illustrations shows a Williams pulverizer with Fafnir $4\frac{7}{16}$-in. double-ball pillow-blocks with extra dust seal. These bearings are under exceptionally severe service, as well as subjected to very dusty surroundings, and operate at about 900 r.p.m. They have operated continuously for the past three years, with no replacements of any kind and are oiled only twice a month. We estimate these bearings paid for themselves the first three months they were in operation by the reduction in oil and repairs alone.

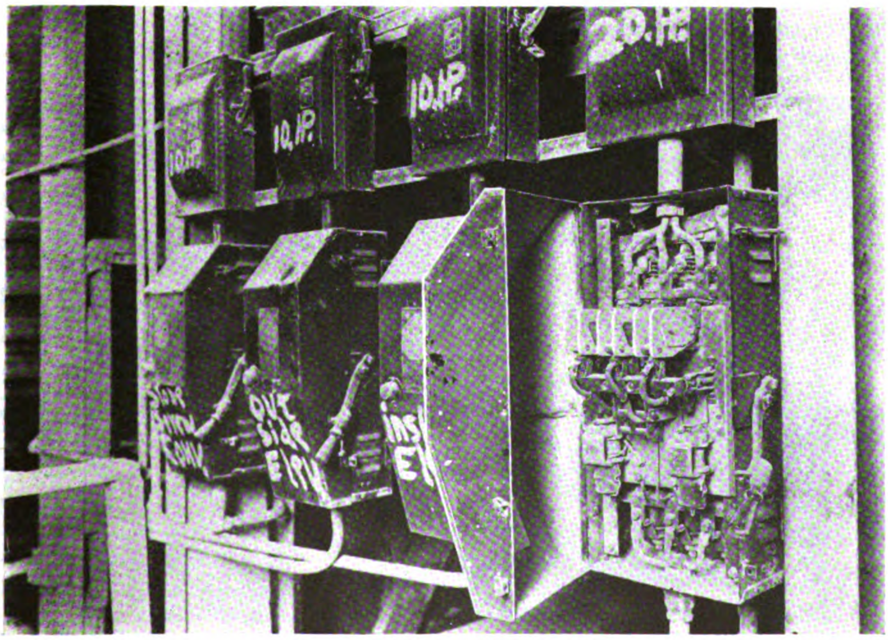
Manufacturers of ball and roller bearings place considerable emphasis upon the saving of power which results from their use. In my opinion the savings that resulted from decreased maintenance and uninterrupted operation are of much more importance. The saving in cost of lubrication is also a considerable item. With plain bearings the interruption of service for replacement costs more than the maintenance labor and material. Also, the shaft wears under plain bearings so that in time a new shaft is necessary, or the worn parts must be cut out. All of these difficulties are eliminated by the use of ball or roller bearings.

In cement mill work care must be exercised to see that bearings of ample size are selected because of the severe service to which they are subjected. Also, particular attention must be given to the dust seal. Most manufacturers of such bearings make several different types of seals, each adapted to varying service conditions. Only the best seal should be considered for cement mill work.

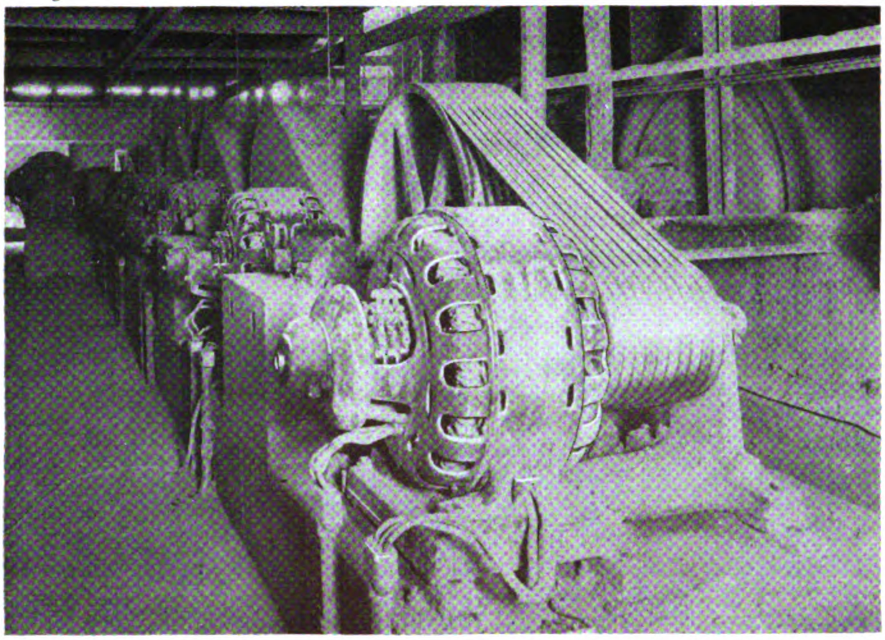
This mill is electrified and is very largely individual drive with a 3,400-hp. connected load. About 160 motors, ranging from 900 hp. down to $2\frac{1}{2}$ hp., are installed. All motors use 440-volt, 60 cycle, three-phase power and a large proportion are operated through Allen-Bradley across-the-line starters with push-button stops. These starters have been adopted as standard on all units of 30 hp. rating and under. Power is generated by a 2,500-kw. and a 1,500-kw Allis-Chalmers turbine supplied with steam from waste-heat boilers. A temporary connection is made with the Louisville Gas & Electric Co. whereby some power is purchased during the peak shipments.

The largest motor, a 900-hp., 180-r.p.m., Allis-Chalmers Hytork synchronous machine, is connected to an 8-ft. x 35-ft. dry ballpeb mill for raw grinding. The starting current is 1,500 amp. and the running current 900 amp. The 35-hp. exciter is driven by a Texrope drive, as shown in an accompanying illustration. We are considering driving this exciter by a separate motor so that the full power of the large motor will be applied to grinding. An Allis-Chalmers bushing-type, flexible coupling connects the pinion shaft to the motor shaft.

Other large motors are two 300-hp., 885-r.p.m. motors driving Bradley mills, a 150-hp. Allis-Chalmers motor direct-connected to a 10,000 g.p.m. centrifugal pump, five 125-hp. Westinghouse motors on 5-ft. x 22-ft. tube mills, three 200-hp. Westinghouse motors on $5\frac{1}{2}$-ft. x 20-ft. tube mills, and some 75-hp. General Electric vertical motors belted to Fuller mills for pulverizing coal. Most of the other motors are Allis-Chalmers make of 10-, 20- or 30-hp. rating. We are standardizing wherever possible on these three ratings not only for motors and controls but also for speed reducers, couplings, pulleys, sprockets, pinions, and so on.



The control apparatus is mounted in groups for convenience of operation.
This illustration shows a group of Allen-Bradley across-the-line starters with push-button stops which control elevators and conveyors. The dust is blown out of these starters periodically. So far as possible, the plant has standardized 10-, 20-, and 30-hp. ratings for driving units, controls, and other auxiliary apparatus, thereby limiting the stock of spare parts.



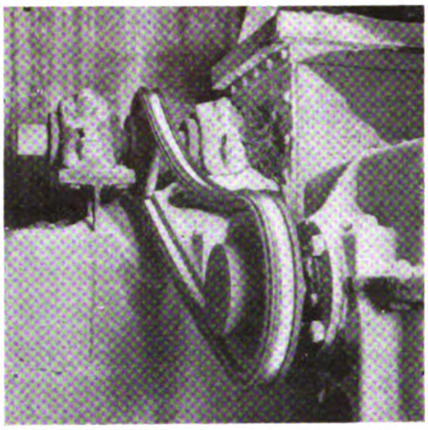
Drives on a battery of five tube mills.
These Texrope drives are of 125-hp. rating and give a reduction of from 580 to 158 r.p.m. The drives have been in operation for more than a year without any adjustment. The first unit has the cover removed to show the drive.

We have also standardized on $2\frac{15}{16}$-in. shafting wherever possible. This includes screw conveyor shafts, conveyor pulley shafts, the few lineshafts in use, and so on. Standardizing on this diameter permits interchange from one unit to another, requires a smaller stock of spare parts, and does not hold us up because a pinion or sprocket will not fit.

All new pinions are heat-treated and supplied by The Tool Steel Gear & Pinion Co. The longer life of the heat-treated pinions more than compensates for the extra cost because of the greater freedom from interruption for changing pinions, as well as having only one installation cost instead of two or three. Any equipment which lasts longer will compensate for any reasonable difference in first cost.

In addition to standardizing the driving equipment we have standardized the construction to simplify inspection and maintenance. For example, the covers on the elevator heads and on the flights of screw conveyors are fitted so that it is not necessary to loosen a single screw or bolt to remove them. However, they fit tightly enough so that they do not slip off accidentally.

A cement plant has comparatively few variable-speed drives. The six pulverized coal feeds on the kilns are controlled by individual Reeves variable-speed units. Variable-speed



Close-up view of a chain drive to a screw conveyor headshaft mounted on roller bearing pillow-blocks.

motors, however, are used to control the speed of the tube mill and coal dryer feeds and kilns.

We are standardizing most of our drives connected to a motor through a speed reducer or through a Texrope reduction. Texrope is used on a number of drives where the reduction ratio is not over 6 to 1. The five tube mills shown in an accompanying illustration are driven through 125-hp. Texrope units. These drives have been operating for more than a year without taking up or any other adjustment. Another similar drive on a crusher has been operating for more than 18 months without adjustment. These drives on the tube mills are enclosed in a sheet-metal guard to protect them from dust, although a number of other drives have not been affected by the abrasive atmosphere even though they are not enclosed.

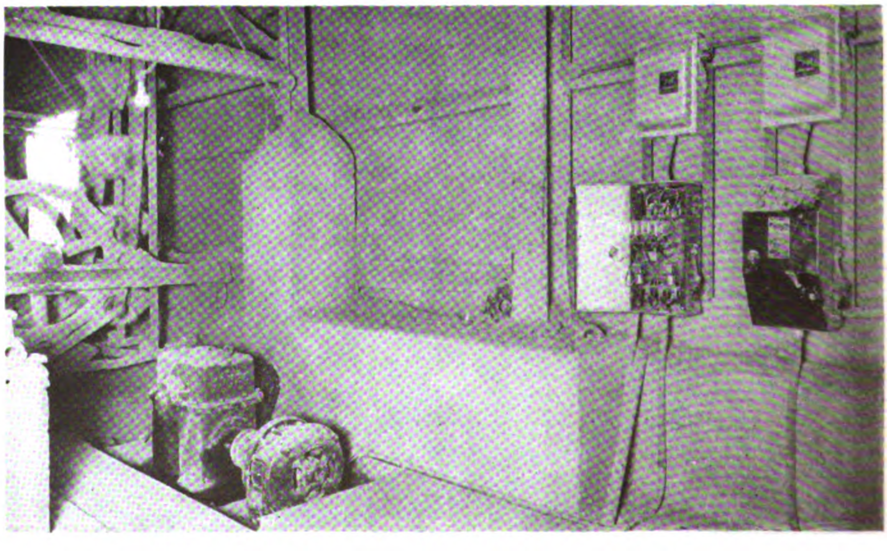
When the centers are longer, Diamond roller chain is used, as, for example, on elevator head and screw conveyor drivers. I find that the open link and sprocket does not wear so much as some of the other types of chains from the particularly severe service and abrasive material in the atmosphere.

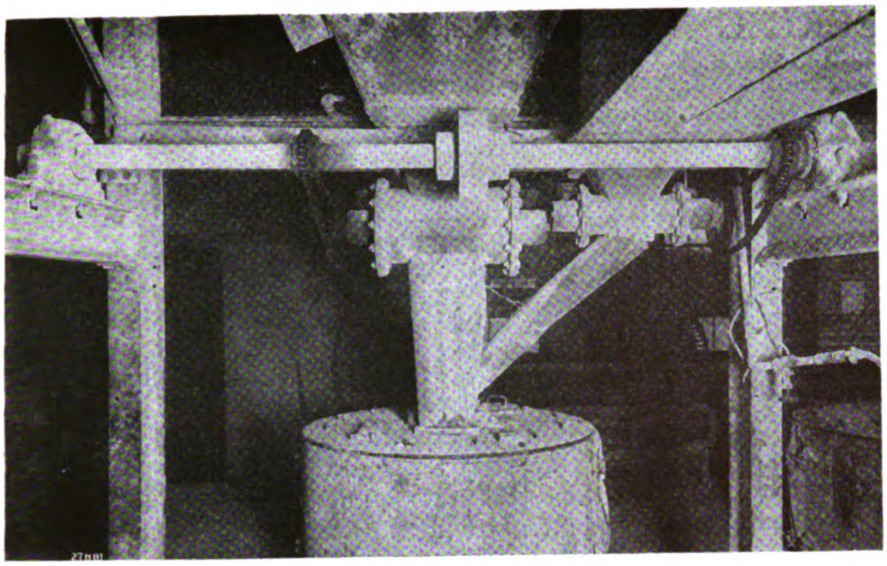
Rubber belts are used to connect the vertical motors to the Fuller mills and on a few other drives.

Equipment operated at a low speed but where the reduction is greater than 6 to 1, such as kilns, dryers, elevators, and belt and screw conveyors, are all driven through a worm reducer connected directly through a coupling, or through roller chains, bevel or spur gears, or various combinations of these.

We are gradually changing over the old speed reducers that were

Speed reducer drive through roller chain to a screw conveyor.
This is a Jones reducer, with Timken bearings on the gear shaft and Strom ball bearings on the worm shaft. The Allen-Bradley control is mounted on the wall at the right. A Trumbull safety disconnect switch is placed ahead of each starter.





One of the few lineshaft drives in the plant.

This 2$\frac{11}{16}$-in. lineshaft is mounted on Dodge-Timken pillow-blocks and is connected to the mixing valves through Diamond roller chains.

installed at first to new reducers of more modern design. The past year or two has seen many important changes made in the design of speed reducers. The new Jones worm gear reducers we are using have Timken bearings on the gear shafts and Strom ball bearings on the worm shaft. In addition, new alloys are used in the worm and gear, improvements have been made in the worm design, and the case is much larger and holds several times as much oil as the case on the old reducer, which, however, represented good design when installed. The old reducers are not worn out and perhaps could be kept going for several years. However, I feel that the modern equipment is more substantial, will require less attention, and will give enough more reliable service to warrant making the change now.

As stated before, we have standardized on three sizes of worm speed reducers. Every installation is carefully considered before the particular size of unit is selected. Overloading is probably one of the most common causes of trouble on drives. In considering the load and service the fact that the equipment operates continuously must not be overlooked. Shock loads also have an important bearing upon the rating. To operate satisfactorily, equipment must be amply rated so as to stand up without overheating or undue wear or strain. Although this is also true of any other industry, the continuous service and the extremely bad operating conditions make it much more important in the cement industry and more allowance is made in the rating.

As stated at the beginning, continuous operation is one of the most important factors in cement production. Even the best of equipment is dependent to a large extent upon the reliability of the drive. In our work of rebuilding the plant, especial attention has been given toward providing drives that will be able to give more reliable service under the severe operating conditions which we must face and which can be improved but little. We still have much to do and will probably be working for the next year or two on the changes we have already planned. By that time, perhaps, something better will come out and require the changing of what we have already placed in service. If the change appears to be worth the cost and will add enough to the reliability of operation we will make it.

Bearing Troubles

(Continued from page 483)

pulley over until the leather-faced flange engaged a tight pulley with a similar flange face. Pressure was continuous against the yoke shoes as long as the loom operated, causing serious and rapid wear of the yoke shoes and the pulley hub due to the fact that lubrication was almost impossible.

As this pulley clutch ran as a loose pulley when the loom was idle, all the troubles of the loose pulley were common to it and bushings wore rapidly, until so great a tipping or canting would take place that the clutching action was a failure. Only then were these pulleys repaired, but in spite of delayed repairs, six to ten men were necessary to maintain these looms, with a consequent loss of production per machine that was very high.

An application of our transmission bearings to the pulley in place of the bushing and the substitution of a ball thrust for the yoke brasses cost hardly more than a single repair. The first trial application is still giving satisfactory service.

H. M. CARROLL, *Hyatt Roller Bearing Co., Harrison, N. J.*—For the past several months our engineers have been making power studies in various plants to determine the saving that can be effected by the substitution of the Hyatt lineshaft roller bearings for plain bearings. Some of these tests have proved very interesting, and it has been found that considerable savings have resulted after the installations were made in accordance with our recommendations.

One of our outstanding surveys was made in the weave room of a large New England textile mill on a line containing 100 2$\frac{3}{16}$-in. bearings and 10 2$\frac{15}{16}$ in. bearings to determine the relative power consumption of plain babbitted bearings and our anti-friction bearings.

Under both tests, no change was made on the system except to replace the 100 2$\frac{3}{16}$-in. plain bearings with Hyatt bearings. The ten 2$\frac{15}{16}$-in. plain bearings were kept in service during both tests.

As determined from the planimeter readings the power consumption when plain bearings were used averaged 81.20 kw. For the Hyatt bearings it averaged 69.80 kw. showing a distinct power saving of 11.40 kw. or 14.06 per cent in favor of these bearings.

A slightly higher figure would have been realized if the ten 2$\frac{15}{16}$-in. plain bearings had also been replaced with the anti-friction type. However, this company's power bill per year is $31,794.96, so that the annual saving effected amounts to $4,769.24, based on the 14.06 per cent saving in power shown by our test. At this rate the entire installation will pay for itself in two and one-half years, on power saving alone.

There is also a considerable saving in the cost of oil and the cost of applying it, as the plain bearings had to be oiled every week, or 52 times a year, whereas the anti-friction bearings require oil only three times a year. However this saving was not included in the above figures.

INDUSTRIAL ENGINEERING

Application and Operation of Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

Published by McGraw-Hill Publishing Company, Inc.

G. A. VAN BRUNT, *Editor*

New York, October, 1927

Helping to Cut the Power Transmission Bill

UNFORTUNATELY, the losses that are most serious in the industrial world are chiefly invisible; that is why they are permitted to occur and to continue. If we could see them, we would soon stop them.

From time to time such of these losses as are involved in industrial wastes are detected and made visible, sometimes through statistical interpretation. When one realizes the magnitude of them he is often astonished.

The head of a large textile plant was once informed by a prominent transmission engineer that the incorrect selection of driving belts in his plant was costing his company many thousands of dollars a year in unnecessary maintenance charges and replacements. He refused to believe the statement until a revision of belts on a "test" section had demonstrated it to be true.

Industry is obliged to pay a tremendous annual bill for its habit of shutting its eyes to losses due to mechanical power transmission through apparatus carelessly chosen, incorrectly applied and poorly maintained.

Individual plants are taxed in no small proportion in order to make up this large total. In the textile mill previously mentioned the loss amounted to more than $30,000 per year simply because of the wrong selection of belts. Thirty thousand dollars per year represents a 6 per cent dividend on a half million dollars of capital stock. It is worth saving.

We believe that this number of INDUSTRIAL ENGINEERING will induce more people to think about their mechanical transmission problems, and thus reveal many dollars of waste that are now escaping unseen in many of our industrial plants.

Consider the Materials Handling Demands of Tomorrow

ONE point often overlooked in the selection of equipment used for handling materials in the industrial plant is that it does not always remain where and as installed. Production changes, shifting of machines, and any of a number of other changes require corresponding extensions, rearrangement, or shifting of the materials handling equipment.

The probability of extensive shifting depends, of course, upon the stability of the particular industry and plant, and numerous other factors. In the case of new industries and new products frequent changes in handling and manufacturing methods may be expected.

The adaptability of the equipment or method of handling to changing or fixed conditions could well receive greater attention in the average industrial plant. Would it be possible to add to the system as installed? Can the equipment be taken down and installed elsewhere without extensive rebuilding? Is it designed to accommodate a reasonable increase in production?

These and many other similar questions should be satisfactorily answered, considering all of the conditions, before any new installation is made. The plant of tomorrow should always be kept in mind when planning for the plant of today.

Do Not Confuse Service With Maintenance

RECENTLY several instances have been noticed where unwarranted demands for service have been made on manufacturers of industrial equipment. In one case a manufacturer sent a service engineer to a large plant nearly 300 miles away, in response to a telegram stating that the automatic control for a large motor was causing serious trouble. The engineer found that a contactor shunt had become loose.

A tactful suggestion that the cause of the trouble could easily have been found and remedied by the plant electrical department was passed over with the remark, "Your company guaranteed this equipment and we expect it to live up to that guarantee."

Doubtless this is an extreme case, but similar, although perhaps less irritating, instances of unjust demands for service are not at all rare.

Every reputable manufacturer is willing to replace parts that are defective, or do anything necessary to make his equipment operate properly. There is, however, a great deal of difference between service and maintenance. No piece of industrial equipment will operate indefinitely without attention. Trying to force a manufacturer to give this maintenance attention, under the guise of a justifiable demand for service, is wrong from every point of view.

For policy's sake a manufacturer may not make a charge for such service calls and it may appear that the user is getting something for nothing. In the long run that is not true. The cost of service, like every other item of expense, must inevitably be reflected in the selling price of the equipment. This means that every purchaser is penalized for the benefit of users who take an unfair advantage. No right-thinking man can find pleasure in the thought that he has helped to bring this condition about.

Engineer a Belt to Its Task

MANY industrial operating men who would not consider laying out a chain, gear, or speed reducer drive without consulting the manufacturer and giving him all the necessary operating data will often blindly select a belt for a particularly difficult drive without asking anyone for advice. Perhaps this is because belts have been used for years and the long acquaintanceship has led him to consider that he knows all that is necessary about a belt drive. However, belting engineers, when investigating reports of unsatisfactory operation, have found many cases where belts were applied without any consideration of fundamental principles.

An example of this lack of knowledge of belts is well indicated by a recent order received by a belting manufacturer. This order called for 2,000 ft. of 3-in. belt for use in an extension of the plant. This manufacturer carries in stock about 30 weights, qualities, and thicknesses of 3-in. belt. Some other manufacturers, by including belts of special tannage, could have supplied about twice as many different 3-in. belts.

The manufacturer sent an engineer to the plant to make a study of the drives and recommend specific belts for the various types of machines driven. Instead of using belt of one width, grade, weight, and thickness, several different types of belts were used and each was engineered to the job in such a manner that the belt manufacturer could practically guarantee the service.

Plant operating men will find it to their advantage to seek expert advice on belt applications, just as they do in the case of other power transmission equipment. They want reliable service from their equipment; this can best be assured by seeking and following good advice.

Carbon-Filament Lamps Have No Place in Your Lighting System

THE modern tungsten lamp has already saved mankind billions of dollars not only in lighting bills but in all the links of electric service from the coal pile to the lighting installation. It has made better lighting possible and, therefore, has conserved vision, increased production, and decreased spoilage and accidents. However, after nearly a score of years since the introduction of the tungsten lamp the carbon filament lamp still survives. More than 18,000,000 carbon lamps were sold last year, notwithstanding the fact that only a few of these had a justifiable economic basis for existence. About 16,000,000 of these were purchased primarily on account of low first cost or unusual bulb shape.

In the earlier years of the tungsten lamp the public was systematically informed that tungsten lamps provide "three times as much light for the same energy consumption." This educational work has practically ceased so that the new generation is, perhaps, not entirely familiar with this point. In any event, the use of carbon filament lamps for general lighting purposes results in a direct waste of money.

Perhaps 2,000,000 carbon lamps were purchased on account of a belief that they are still more rugged than the tungsten lamps—as they used to be. Recently, however, rough-service tungsten lamps have become available so that in most cases carbon lamps can be satisfactorily superceded by a more efficient type.

The use of carbon lamps is not justifiable excepting in very special cases that do not ordinarily arise. Elimination of waste is one of the slogans of the day, and waste certainly has no place in lighting or in electrical development.

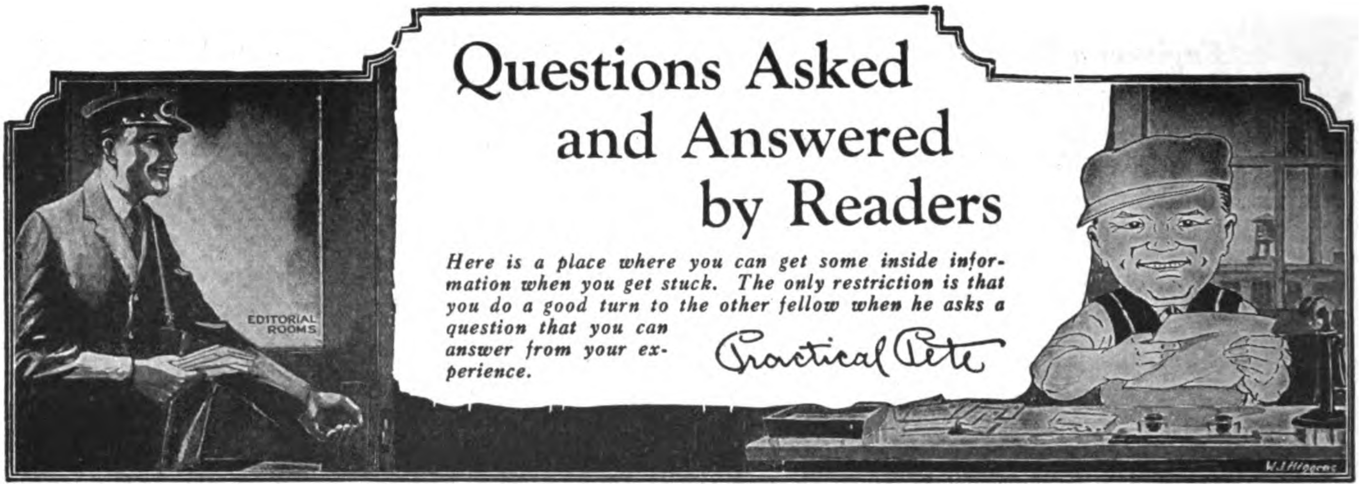
Standardization of Electric Motor Frames

PROGRESS is being made in the standardization of important dimensions governing the interchangeability of electric motors of different makes. According to an announcement by the American Engineering Standards Committee, two prominent organizations, the American Society of Mechanical Engineers and the National Electrical Manufacturers Association, have accepted joint leadership in the development of such standards.

Machinery everywhere is more and more becoming motorized, being driven either by self-contained electric motors or adapted to easy application of motor drive upon installation. This is particularly noteworthy in the case of metal and woodworking machinery of every description, refrigerating machines, foundry equipment, printing presses, steel mills, and so on. However, owing to variation of dimensions in different makes of motors, specific and detailed information is often necessary with each new application. In some cases significant changes in design have been required to accommodate some particular make of motor.

The National Machine Tool Builders Association, which found diversity in motor dimensions a problem of particular difficulty, filed the original request to have the subject taken up by the American Engineering Standards Committee. At a conference, to which all parties interested in this subject were invited, the scope of the work was defined to include standards for shaft height, distances between bolt holes at right angles to, and parallel to, the shaft, certain combinations of shaft height and distances between bolt holes, and maximum diameter and length of motor.

Undertaking of this important work by the N.E.M.A. and the A.S.M.E. is good news to operating men, for it will eventually lead to the solution of a troublesome problem.



QUESTIONS

Who Can Answer These?

How Much Power Can Be Saved by Realigning Shafting?

We wish to increase the load in one of our old mills. Our engine is loaded to capacity and I should like to know (1) if readers have found that the power saved by carefully realigning all shafting in their plants makes a noticeable reduction in the total amount of power consumed, and if so, about what percentage? (2) After the shafting is properly lined up, how often should it be checked? (3) Is there a simple but accurate method that may be employed to check the alignment?
Gt. Punxsutawney, Pa. P. F. D.

Power Factor of Generator Used as a Motor

As all the electric current used in our plant in the future will be purchased, we would like to make use of an a.c. generator that was formerly driven by a steam engine, as a synchronous motor. This generator was rated at 80 per cent lagging power factor. Will its power factor be leading or lagging, when used as a motor? Will some reader please explain why?
Northampton, Mass. L. G. D.

Deterioration of Pipe Drainage System

It is supposed that much of the deterioration in some of our pipe drainage system is due to electrolytic action caused by our plant haulage system, which is operated on direct current. Insulating the joints between some of the pipe sections, electrically connecting all adjacent pipe ends and connecting the pipe line to the tracks are some of the remedies that have been suggested for the trouble. Whether or not readers believe the railroad is causing the trouble, what can we do to stop the deterioration of the pipe?
Pittsburgh, Pa. V. McL.

Inspection of Transformer Oil

I wish readers would give me their opinion on the following questions: (1) How often should the oil in transformers be inspected? (2) What are the minimum safe dielectric values of such oil for various operating voltages, as determined by the sphere gap testing equipment? (3) What differences may be expected from such tests on samples taken from the top and the bottom of the transformer? (4) Is there any limit to the life of transformer oil if tests show it to be clean and its dielectric value satisfactory? (5) Are periodic tests of the insulation resistance from the high side to ground, from high to low side and from low side to ground of any value on oil-filled transformers?
Cleveland, Ohio. J. M. S.

Is this Ground Detector at Fault?

When our three-phase a.c. distribution system was revamped, so that all circuits could be controlled from a central point, a three-phase, Type TG, Westinghouse electrostatic ground detector was connected to the main 2,300-volt bus. When installed the dot on the moving vane coincided with the etched ring on the glass cover but recently it has indicated a ground between two phases that I cannot locate with a Megger. When the bus is entirely disconnected, the vane rotates about 180 deg. before coming to rest, off center, but if cut out of service for several days, it will take the zero position. Will readers who have had similar trouble tell me if this action indicates faulty condensers? Or is it due to the unbalancing caused by a heavy, single-phase heating load?
Kearny, N. J. A. D. S.

Automatic Starting of Motors After Failure of Power

We have six pumps in our mine driven by three-phase, 60-cycle, 440-volt, squirrel-cage induction motors ranging in size from 3-, to 7.5-hp. rating. The current supply to these motors is frequently interrupted by trouble in the feeder lines to the mine; also slate-falls in the mine often break one of the three-phase wires leading to one of the motors. Will readers kindly tell me what methods to employ so as (1) to protect the motors from overloads and single-phasing, and (2) automatically start the motors upon restoration of power after failure?
Eckman, W. Va. D. C. W.

ANSWERS

Received to Questions Asked

Trouble in Setting Circuit Breakers

We have had difficulty in accurately setting our three-phase, 550-volt oil circuit breakers, which range from 80- to 400-amp. rating. I shall appreciate it if readers will tell me the best method of making this adjustment, by the use of a phanton load. Can a water rheostat be used as the load, or is some other device more suitable?
Vancouver, B. C., Can. • A. M. S.

ANSWERING A. M. S.'s question, it is possible to use a water rheostat in the test circuit, but if a job can be done with some other type of resistance, it is highly advisable to do so, for home-constructed water rheostats are ordinarily dangerous to life and equipment and besides are not well adapted to this type of testing.

In setting circuit breakers, I use the General Electric meter-testing rheostat with rheostat control. This instrument can be purchased with or without the rheostat, but it is advisable to invest a few extra dollars to obtain the finer control.

In connection with the rheostat I use a stop watch and ammeter, and through their use a very accurate setting can be determined. I might add that our oil circuit breakers are protected through the G.E. I A 201 overload relays, and the settings obtained are very accurate.

E. J. Morrissey.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

IN REPLY to the question by A. M. S., the most dependable practice to assure the proper operation of an oil switch is to apply to the tripping coil, from a separate circuit, the load desired for the breaker to open. At the same time allow the entire oil breaker to function, in order to make certain all parts are operating.

To set an oil breaker by placing the adjustment indicator, or pointer, at the figures marked on the switch is not good

practice, as the breaker may operate at a value below or above the desired load. I presume that the breakers in question are operated under overload conditions from the secondaries of current transformers. In this case a phantom load of 5 amp. will suffice for the testing of the tripping point, excepting where circuits are carrying an overload current that is above the rating of the current transformer.

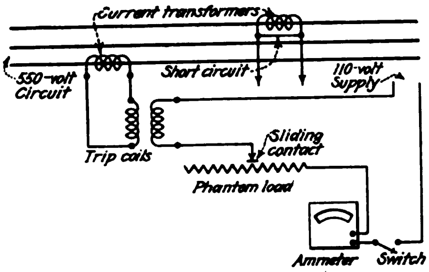
In setting an oil breaker it is not very handy to use a bank of lamps for the test load, but about 50 to 60 ft. of No. 22 Nichrome wire wound around a porcelain tube and cemented to keep the turns in place should prove satisfactory, allowing enough exposed surface to slide a moving contact over the turns. This sliding contact may be made from a fuse clip and an ordinary water kettle cover handle. When a 110-volt test circuit is used, any load from 1 amp. up to 20 amp. can be obtained.

As indicated in the accompanying illustration, all that is necessary to test the trip coils is a phantom load, one ammeter, a single- or double-pole single-throw switch and a 110-volt single-phase circuit.

The test is made by first short circuiting the secondaries of one current transformer and disconnecting the secondaries from the tripping coil. Connect one side of the 110-volt circuit to one terminal of the single-pole switch. The other side of this switch is connected to the ammeter and the second terminal on the ammeter is connected to the phantom load. The other side of the 110-volt circuit is also connected to the phantom load. Open the single-pole switch, move the sliding contact along so that most of the Nichrome-wire coil is placed in circuit, and then switch on the 110-volt supply. Next close the single-pole switch and observe the ammeter. Adjust the moving contact until the desired load is obtained. The ammeter reading, of course, is to be multiplied by the current transformer ratio in order to determine the amount of line current needed to trip the breaker.

When the desired load has been obtained, open the switch in the test circuit, disconnect the side of the phantom load connected directly to the line, and connect this terminal to the trip coil. The other end of the trip coil should be connected to the line. Close the oil circuit breaker, then close the switch in the test circuit, placing the test current through the coils.

Should the oil breaker open immediately, do not take it for granted that it trips at the proper point. Lower the current in the test circuit until a point is reached where the oil breaker will not open when the test current is applied. Then gradually adjust the current setting upward, at the same time increasing the current in the test circuit until the desired tripping value is reached; until it is finally determined that the oil switch will not open at any load below that which you desire it to operate. When each tripping coil is tested in this manner, it is definitely known just what load will trip the circuit.



How to connect a phantom load to a trip coil.

It is a good practice to keep a record of all these tests and settings made on each breaker for reference. The usual practice is to keep an "as found record" and an "as left record," which may be very useful to refer to from time to time.

E. J. ELVISH.

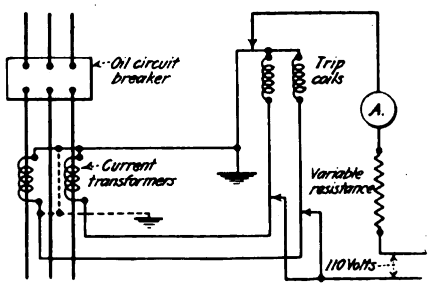
Maintenance Inspector,
Kaministiqua Power Co.,
Fort William, Ont.

IN REPLY to A. M. S.'s question, assuming that the oil circuit breakers used are hand operated and are opened by current from a current transformer supplied to a trip coil, and that no relays are used, I would suggest the following plan:

First, the current transformer ratio should be checked to find the current flow required in the trip coils to operate the breaker at the desired load. Then the secondaries of the current transformers must be short circuited as indicated in the diagram by the dotted lines, and the circuit to the trip coils opened. After doing this and using a 110-volt source of current supply, an ammeter and a suitable resistance can be placed in series first with one trip coil and then with the other. Then set the plunger on the trip coil at a point where the breaker trips out when the required amount of current is allowed to flow in the coil.

For instance, let us assume that the current transformer ratio is 60 to 1 and the load at which the breaker is to trip is 300 amp. Then the current in the trip coils necessary to trip the breaker at a 300-amp. load can be calculated as follows: $60:1 = 300:x$; $60x = 300$; $x = 5$ amp. In this case it would simply be necessary to set the plunger of the trip coils to a point where the breaker would trip out when 5 amp. is flowing in the trip coils.

How to connect a test circuit to the trip coils of a circuit breaker.



FRANK C. AMMANN.

Plant Electrician,
Sioux City Gas & Electric Co.,
Sioux City, Iowa.

Checking Condition of Elevator Cables

We are using the ordinary 6-19 cables on most of our elevators and I wish readers would give me some suggestions on inspecting them for condition. Can our maintenance men determine when these cables need to be replaced by counting the broken strands? If not, what other methods or tests can we employ that will safely determine this point? I shall appreciate any help from readers.
Auburn, N. Y. H. W. J.

IN REPLY to H. W. J.'s question, the usual method of checking the condition of elevator hoist cables consists primarily in examining them carefully for broken wires. This examination must cover particularly all portions of the cable that pass over the sheaves or drums, because the wear and subsequent breakage of the cable appears, under ordinary conditions, on those sections of the cable that are subjected to repeated bending around the sheaves.

When the elevator machine is located in the basement it will be necessary to go into the overhead work and examine that section of the cable which passes around the overhead sheaves, but never gets down to the machine. With overhead machines, unless they are roped in a 2:1 ratio to the car and counterweighted, the entire length of rope subjected to bending may be examined at the machine.

When the car and counterweight are roped 2:1, attention must be paid to the sections of the rope near the multiplying sheaves on the top of the car, or under it, as the case may be, and the top of the counterweight.

If more than five or six of the individual wires that make up the strands are found to be broken per inch in a given section, it is time to renew that particular cable.

Cables may wear considerably and yet not show any broken wires. By this I mean that a thinning or flattening of the wires may take place, imparting a bright, shiny appearance to the whole cable. At this stage of its life the cable must be watched very carefully, as breakage of the wires is imminent. On the other hand, broken wires may appear when there is hardly any sign of wear on the cable. In such cases it is generally an indication that the rope has been overloaded, or that the wrong kind of cable is being used. The cable may be too stiff, or it may be too large for the diameter of the sheaves with which it is used.

J. M. WALSH.

Asst. Chief Engineer,
Gurney Elevator Co.,
New York, N. Y.

Cutting Out Damaged Coil in Winding

Will some reader please give me a diagram of a chorded split-loop winding showing the method of cutting out a damaged coil? I should also like to know if this type of winding does not have a much longer lead throw than the straight loop winding. Can it be wound with two wires in hand and connected to a commutator with twice as many bars as coils? Would the method of cutting out a coil be the same as when wound with one wire in hand? J. B.
Los Angeles, Calif.

REGARDING J.B.'s question, a chorded split-loop winding can be wound with any number of wires in hand; that is, two when bars × slots = two, or three when there are three times as many bars as slots, and so on. The lead throw of any type of winding depends on the position.

A diagram is not needed to show how to cut out a coil, for all that is necessary to locate the defective coil is to trace its leads to the two commutator bars to which the coil connects. Then cut open the defective coil and put a jumper across the bars to which the coils connect.

The method of cutting out the coil is the same regardless of the number of wires in hand.

A. C. ROE.
Renewal Parts Engineering Dept.,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

What Causes Blowing of Fuses on Transformer Bank?

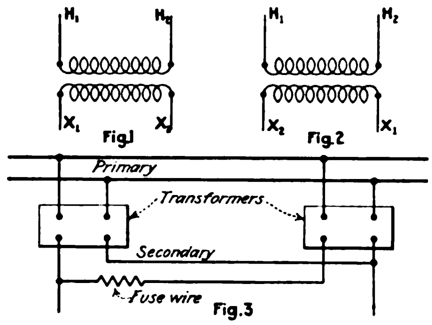
We have two 50-kw. transformer banks serving separate heating loads and when they are connected in parallel on the secondary side the fuses blow on one bank. Everything on the nameplates of both banks corresponds except the polarity. One bank is marked Subtractive, while the other is marked Additive. Will readers explain the meaning of these markings, and tell me if this difference in polarity has anything to do with the blowing of the fuses? H. B. D.
Lynn, Mass.

IN ANSWER to H. B. D.'s question, evidently the polarity markings are wrong or they have been misunderstood. As the additive polarity is exactly opposite to that of the subtractive polarity of transformers, it will first be necessary to ascertain whether the transformers are tied together on the same phase. If they are, then reverse either the primary or secondary side of either one of the transformers that are banked together.

When transformer leads are marked in accordance with the National Electric Light Association rules, the polarity of a transformer is subtractive when H_1 and X_1, as indicated in Fig. 1 in the accompanying illustration, are adjacent, and additive when H_1 is diagonally opposite X_1, as in Fig. 2.

Single-phase transformer nameplates should in all cases be marked as either of subtractive or of additive polarity, so as to indicate definitely the polarity of the transformer to which the nameplate is attached. The older types of transformers, however, did not have these markings.

Two simple tests for the determina-



How a fuse is used to test the connections between the secondaries of additive and subtractive transformers.

tion of polarity are recommended as follows:

First Test—For small transformers, where current values are not excessive, connect the primaries in parallel to the supply circuit. Then connect the secondaries in parallel, with a fuse in series with one line, as shown in Fig. 3. If the transformer polarities are the same, the fuse will remain intact when the primary voltage is applied; otherwise the fuse will blow before the transformer is damaged.

Second Test—For large transformers, where the current is relatively high, it is not advisable to use the fuse-wire test. In this case the same general arrangement of connections should be used, but the fuse wire should be replaced with a potential transformer that is suitable for twice the secondary voltage, a lamp bank, or a voltmeter. No voltage at the fuse position, Fig. 3, indicates that the transformers have been correctly connected.

On the other hand, if voltage is observed, reverse either the primary or secondary leads of only one of the transformers.

H. J. ACHEE.
Superintendent,
Water & Light Dept.,
Woodward, Okla.

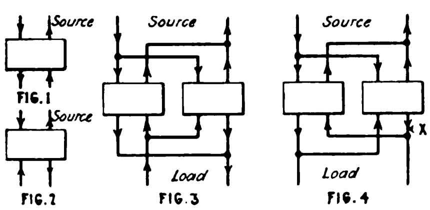
ANSWERING the question by H. B. D., it is assumed from the description given of the trouble that the fuses blow as soon as the transformer banks are paralleled. The questioner does not state whether the banks are single phase or three phase. The general explanation can, however, be given on the basis of single-phase banks, since the principle involved is the same. Fig. 1 shows a transformer with leads brought out to give subtractive polarity; Fig. 2 shows lead brought out to give additive polarity.

In both of these cases the source is assumed to give a current flow through the transformer in the same direction, the arrows indicating the direction of instantaneous flow. Fig. 3 shows the correct connections for paralleling two banks when one transformer is of subtractive and one of additive polarity. Fig. 4 shows two banks incorrectly connected when the polarities are different. It will be noted that on the load side there exists a dead short circuit, consequently the fuses will blow.

In paralleling transformers as indicated in the illustration, a lamp bank or voltmeter should be used on the low-voltage side, say at X in Fig. 4, and the leads only connected permanently when the voltage is zero, or approximately so, between the lead ends. Should the voltage be higher than, say, 600 volts, a potential transformer should be used. In any event the instrument potential transformer, or perhaps in some cases a lamp bank, should be arranged to accommodate twice the voltage of one bank.

C. OTTO VON DANNENBERG.
Electrical Division,
Industrial Engineering & Management Corporation,
New York, N. Y.

Additive and subtractive transformer connections.
A subtractive polarity transformer is shown in Fig. 1, one of additive polarity is shown in Fig. 2. The correct way of connecting additive and substractive polarity transformers is shown in Fig. 3, and an incorrect way of connecting them is shown in Fig. 4.



Can Formation of White Incrustation on Brick Be Prevented?

Our main office building is built of pressed red brick, most of which is covered with a white, salt-like incrustation that is very unsightly. Part of this can be brushed off, but it soon forms again. We do not want to paint the building if it can be avoided and I should like to know if there is any treatment that can be applied to the bricks that will prevent the formation of this white coating. R. P.
Chicago, Ill.

REFERRING to the question by R. P., there is a material on the market called Brixope which is sold for the purpose of removing and preventing white incrustation on brickwork.

After as much dirt and white stain as possible has been dry brushed from the wall the prepared material is scrubbed on and cleans off the remaining efflorescence and at the same time waterproofs the wall. This material is largely used in the building business for this purpose. It is claimed that the results obtained by this material are more permanent than if an acid substance were used. In addition it will not burn or harm any of the materials commonly found on a wall.

IRVING KASS.
New York, N. Y.

IN REPLY to the question by R. P., after rather extensive observations of brick walls, I believe that the white incrustation he mentioned is due to a lime formation that originates in the brick and mortar. To remove the white

incrustation, wash the wall with weak muriatic acid.

The affected bricks usually appear in groups, and those places in the wall where water can enter even to a limited extent are generally the locations of the greatest amount of incrustation.

To prevent the water from seeping into the wall, calk the joints and cracks with some form of asphalt or elastic roofing cement. After this is done, the wall surface should be treated with some suitable substance that will prevent the returning of the white incrustation.

H. D. Fisher.

Plant Engineer,
New Haven Board & Pulp Co.,
New Haven, Conn.

ANSWERING the question by R. P., although painting the wall may prevent the formation of the white incrustation for a time, it will be necessary to repaint the wall as the paint wears off. This repainting process in some cases will be rather expensive.

There is another method, however, which I would recommend in preference to all others. After cleaning the walls of all incrustation and other foreign matter, apply a waterproof oil in the same manner as you would apply paint. By properly working the oil into the pores of the brick and cement mortar, a waterproof wall will result. There is a waterproof oil sold for the specific purpose of preventing the formation of this white incrustation on the surface of brick walls.

Nathaniel W. Blanchard.

Inwood, N. Y.

Eliminating Radio Interference from D. C. Generator

Interference with radio reception in our community has been traced to one of our 100-kw., 230-volt, 275-r.p.m., Type N, engine-driven Westinghouse generators. We ground the commutator and adjusted the brushes and holders so that there is no sparking, but the only way that the trouble can be stopped is by pulling the main switch, or by reducing the voltage from 230 to 160. When the voltage is raised, the trouble returns. The radio interference seems to be greatest at one end of the engine stroke; in town it is possible to count the revolutions of the engine on a radio set. I believe that the engine speeds up at the end of one stroke, thereby increasing the generator voltage. If condensers are a practical remedy for the trouble, what size should they be? How should they be connected to the generator? What other method could be used to rectify the trouble? We are very anxious to get this situation cleared up and I shall appreciate any help you can give me.

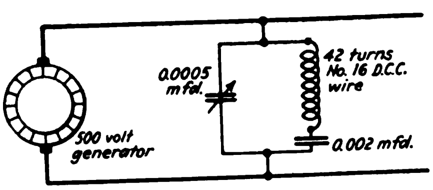
Vandergrift, Pa. G. J. K.

IN ANSWERING G. J. K.'s question, he should not have any real difficulty in clearing up this radio interference if he will follow these suggestions.

First, eliminate as much of the sparking of the brushes as is possible. Second, I would recommend the use of a Tobe filter for that particular size of d.c. generator. This filter should be installed according to the directions that come with it. These filters are very compact, measuring 10 in. x 6 in. x 2 in. Third, wind an inductance coil made up of 42 turns of No. 16 d.c.c. wire on a 3-in. diameter core, and connect it as shown in the illustration with a 0.005-mfd. variable condenser, and a 0.002-mfd. fixed condenser across the generator leads.

Geo. R. Conklin.

Radio Engineer,
Southwest Light & Power Co.,
Elk City, Okla.



One way of preventing radio interference by employing an induction coil, a fixed and a variable condenser.

Why Does This Commutator Wear Out of Round?

The life of a new commutator on one of our 3-hp., 230-volt, d.c., 1,150-r.p.m., style SK, Westinghouse motors is very short. This motor, which is belted to a suction fan, is located in a room where lead is melted and cast into bars. In an attempt to overcome our trouble we have tried different brushes, undercutting the commutator, and used good armatures from other machines, but about every three months the commutator becomes egg-shaped. Is it the acid or gas fumes, or something else that is causing the trouble? I shall be grateful for any information that readers can give me.

Chicago, Ill. F. J. C.

REPLYING to the question by F.J.C., a commutator wearing egg-shaped is rare indeed. This trouble may be caused either by the belt action or the acid fumes.

If it is found that the belt is causing the trouble, the use of an endless belt and the elimination of any belt slap should remedy trouble from this source.

It is quite probable that the acid and gas fumes in the atmosphere, which attack mica insulation, may be the cause of the commutator wearing egg-shaped. In order to avoid this trouble the mica should not be undercut, but run the commutator with the mica flush, for the dirt that collects in the slots soon becomes contaminated with acid, and then, of course, the mica and segments will be affected. The fumes in the air will also attack the V ring, and cause it to shrink. As this action will cause the segments to loosen, it may be the cause of the trouble experienced.

W. E. Warner.

Shefford, Bedfordshire, England.

IN REPLY to F. J. C.'s question, there may be some electrolytic action causing the commutator trouble but in this case it surely would affect the whole surface of the commutator and not part of it. In case the fan is belt driven the belt lacing might be the cause of the trouble. High mica or soft copper in the bars would also cause trouble. Rubbing the commutator lightly with vaseline about once a week might lessen the trouble.

I would suggest that F. J. C. test the armature for balance, and eliminate all vibration possible. At this time the air gap can also be checked. Besides testing all fields for the short-circuited coils and grounds it might be well to check the brush spacing and be sure that each brush has the same thickness.

If acid fumes are the cause of the trouble, the obvious remedy will be to inclose the motor so that these fumes cannot enter it. One sure way of determining whether the fault is due to inherent defects in the machine or to the nature of the drive would be to replace this motor with another one, in order to observe what effect this particular drive has on the new motor.

Grady H. Emerson.

Birmingham, Ala.

ANSWERING the question by F. J. C., the trouble referred to may be due to several causes, the most common being high mica, looseness, or an unseasoned commutator. The questioner states that the mica has been undercut; so it is reasonable to assume that the trouble is not due to high mica. If, however, the commutator is not tight, that is, if the bolts are not drawn up as far as possible, heating will cause it to expand and change its shape.

From the description of the operating conditions it does not seem unlikely that the room temperature may at times be higher than the usual conditions and so cause the whole machine to operate at a higher temperature. F. J. C. should make sure that the holding bolts are as tight as possible. It is, of course, not possible in the usual case to go to the trouble of removing the commutator and heating it in an oven; so the following methods are suggested:

(1) The commutator may be heated with a gasoline torch, preferably with the armature mounted on horses and slowly revolved while the flame is moved over the surface of the commutator parallel to the shaft. This method is used by many repair men, although it requires considerable experience and judgment to avoid overheating and should be carried out with much caution.

(2) Another method is to shift the brushes very slightly so that they will spark when the motor is operating. The motor is allowed to run for about an hour and then shut down and the bolts tightened. It is then allowed to run for another hour and the same procedure followed. In this way the expansion can be taken up gradually.

(3) A method used by a manufacturer consists in driving the motor by another one and bearing down on the commutator with a maple block. This method is very readily carried out in a repair shop and heat is generated quite rapidly, so that the bolts can be tightened within a short time; it also keeps the surface in fairly good shape. With this method it is, of course, necessary to remove the brushes.

With any of the foregoing methods it is necessary, after the tightening has been completed, to resurface the commutator.

C. Otto von Dannenberg.

Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

New Equipment

for plant operation and maintenance

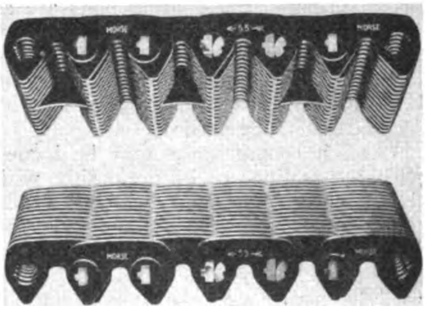
Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Rocker-Joint Chain

ANNOUNCEMENT has been made by the Morse Chain Co., Ithaca, N. Y., of an improved chain. The improvements consist principally of changes in the design of the rocker joint.

The new 55 type chain will operate on present design of sprockets, the new link being the same length and height as the old. The new joint, as shown in the accompanying illustration, operates on the same principle as the original Morse rocker joint. The seat pin, at the left, has been enlarged to give greater bearing surface and also to make it a stronger transverse member to hold the chain together. The rocker pin, at the right, has been changed in contour, thereby giving a better surface contact with the links.

The combined joint members give a



Morse Rocker-Point Chain

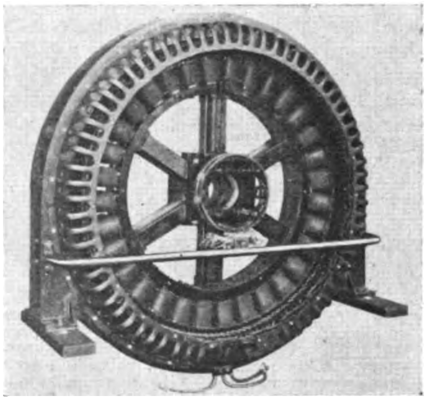
more nearly round hole with reduced clearance, holding the links more securely on the pins. The joint pins are about 8 per cent heavier and the complete chain weighs twice the pitch per inch foot. The breaking strength, it is claimed, has been increased about 50 per cent.

Arc-Welded Synchronous Motor

A NEW low-speed synchronous motor, called the Type HR, has recently been placed on the market by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. This motor, which is of arc-welded construction, has been specially designed for ease in handling and ease in assembling in the field.

Material reduction of the excitation, a starting torque of 50 per cent and a pull-in torque of 40 per cent are claimed as features of this new motor which is shown in the next column.

The shape of the rotor arm in this new motor is such that a large amount



Westinghouse Type HR, Low-Speed Synchronous Motor

of air is set in motion, and this air is so directed that it not only passes through the stator coils but also passes over a large area of the stator laminations. By means of different weight rings bolted to the rotor rim, six possible values of flywheel effect are available.

This motor is said to be particularly desirable for driving refrigerating machines and air compressors; when direct-connected it is equally desirable for driving jordans, pulp grinders, pumps and other slow-speed machinery of this character.

Lifting Magnet

MARKETING of a lifting magnet, known as Type SA, has been announced by the Electric Controller & Manufacturing Co., Cleveland, Ohio. The coil spider of composite construction, with a body of cast steel and a flange of cold-rolled brass, provides greater strength and better lifting capacity, it is claimed, than a one-piece, cast-brass spider.

In the new design the outer pole shoe is extended upward to fit against a machined surface on the outside of the magnet housing, giving greater strength for the purpose of preventing pole shoe breakage.

A steel plate ½ in. thick is bolted in place at the top of the magnet to prevent injury to the incoming lead wires from the crushing effect of the crane hook and chains.

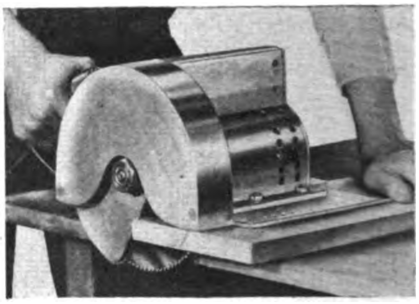
Electric Controller & Manufacturing Co. Type SA Lifting Magnet

Portable Electric Saw

A LIGHT portable electric saw is being marketed by the Lee Pattern Co., 130 13th St., Milwaukee, Wis. It weighs 6 lb. and it is said will cut lumber up to 1 in. in thickness.

This saw is primarily a one-hand tool, and due to its shape, it can be laid down on any of its four sides without rolling over.

The saw is equipped with an automatic guard that is said to insure safety at all times. If necessary, the guard can be changed for the use of a left-handed workman. A patented ridge is provided for gripping the machine in a vise, so that it can be used as a regular bench saw. This vise grip can also be used as a hand grip for pushing the saw through the work.



Lee Portable Electric Saw

Oil Circuit Breaker

A MANUALLY operated indoor oil circuit breaker known as Type E-20, specially designed for the protection of large motors and for general utility in the industrial field, has been placed on the market by the Condit Electrical Manufacturing Corporation, Boston, Mass. The application of a thermal overload trip device to this oil circuit breaker, affording time lag overload protection, is one of the distinct features.

The housing and frame are of heavy-gage pressed steel, the housing being firmly welded to the frame on all four sides completely inclosing all of the live parts. The cover is a single piece turned at the edges.

Both movable and stationary contact members are extra heavy, the movable contact being strongly supported in a heavy carriage and provided with helical springs which maintain a high pressure on closing and facilitate the opening of the movable member.

Type E-20 Oil Circuit Breaker Manufactured by the Condit Electrical Corporation

The circuit breakers are equipped with a position indicator, which indicates whether they are in the open or the closed position.

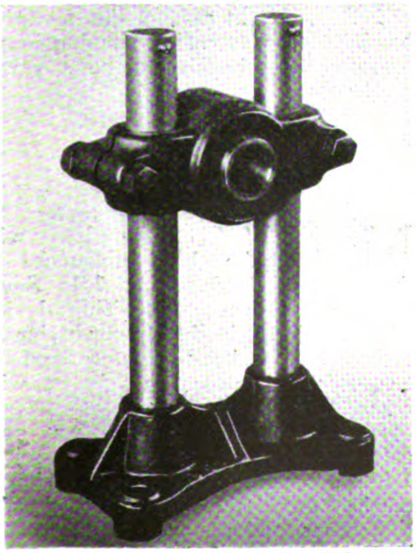
Overload tripping is accomplished by the use of a mechanical thermal tripping device used in conjunction with current transformers. This Type E-20 circuit breaker is furnished for 400 amp. or less, three poles, and has an estimated interrupting capacity of 2,400 amp. at 2,500 volts.

Adjustable Outboard Bearing

DISTRIBUTION of a line of adjustable outboard bearings, one of which is shown in the accompanying illustration, is announced by the Boston Gear Works Sales Co., Norfolk Downs (Quincy), Mass. These outboard bearings are furnished either with or without bronze bushings and accommodate shafts ranging from $\frac{3}{4}$ to $2\frac{3}{8}$ in. in diameter.

Boston duplex bearings can be used in these adjustable supports which are of sturdy construction. These bearings are used for special or temporary construction, and for countershafts or jackshafts and similar purposes.

Boston Adjustable Outboard Bearing

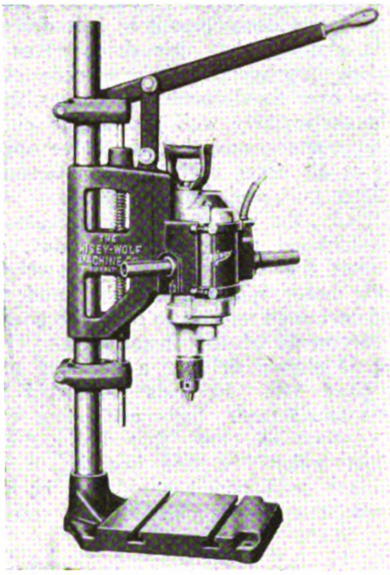


The over-all heights of these units vary from $5\frac{1}{2}$ to $12\frac{3}{8}$ in., and the base dimensions from $2\frac{5}{8}$x$4\frac{1}{8}$ in. to $5\frac{1}{4}$x$10\frac{3}{8}$ in. The maximum base-to-center distance is from $4\frac{1}{4}$ to $10\frac{3}{4}$ in. and the minimum from $1\frac{7}{8}$ to $4\frac{1}{2}$ in. The various units weigh from $2\frac{1}{4}$ to 28 lb., according to the bore.

Drill Stands

NEW drill stands can now be supplied for post or wall mounting, in addition to the conventional bench design by the Hisey-Wolf Machine Co., Cincinnati, Ohio.

The stands, one of which is shown in the illustration, are made for all sizes of Hisey electric drills from $\frac{1}{4}$-in. to $\frac{7}{8}$-in.



Hisey-Wolf Electric Drill Stand

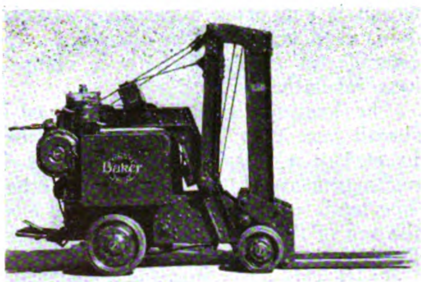
capacity. They are designed so that the portable drills can be attached without moving a single part of the machine. The facing surfaces of the supporting bracket, as well as the drill housing, are machined to insure proper alignment of the drill in the stand.

Tin-Plate Truck

A NEW type of tin-plate truck has recently been put on the market by the Baker-Raulang Co., Cleveland, Ohio. This truck, which is shown in the accompanying illustration, has a capacity of 5,000 lb. of sheets and is small enough to be driven inside the average box car.

The driving axle is of the full floating type, with a $17\frac{1}{2}$:1 worm gear reduction. The motor is mounted on a cradle cast integrally with the axle housing. To provide easy steering, the knuckle pivots are in line with the tire centers.

The controller is the standard Baker all-metal type with renewable segments and renewable fingertips. An automatic switch of the quick-break type with auxiliary carbon contacts is provided as a safety feature. It is interlocked with the controller and prevents the opera-



Baker-Raulang New Type Tin-Plate Truck

tion of the truck except by a conscious and sustained action on the part of the operator.

The hoist consists of two drums, either of which may be driven by a series-wound motor. A selector switch operates a set of magnetic clutches and determines which drum will be driven when the power is applied. One cable hoists the carriage and forks and the other tilts the superstructure. When picking up a load, the superstructure is normally vertical and the forks will lift high enough to stack loads one upon the other. When unloading, the superstructure may be tilted a little forward of the vertical position in order to bring the points of the fork prongs into contact with the floor.

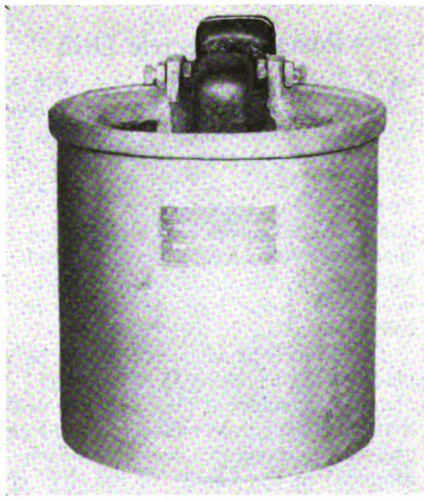
Limit switches are provided to open the hoist-motor circuit at both limits of travel of the carriage and of the superstructure.

Electric Melting Pot

A NEW electric melting pot has been introduced by the General Electric Co., Schenectady, N. Y., for melting solder, lead, babbitt, tin and the like. It has a capacity of from 27 to 40 lb., according to the metal to be melted. This pot may be operated on either a 110-volt or a 220-volt alternating or direct-current circuit and is made in two ratings—750 and 1,000 watts.

The new pot is the smallest size of the G.E. RP form E line. It consists of a sheet-steel cylindrical casing 10 in. deep and 9 in. in diameter, inside of

G.E. Small-Capacity Melting Pot



which is supported a cast-iron crucible 4 in. deep and 6 in. in diameter. The crucible is insulated with a compact heat insulator.

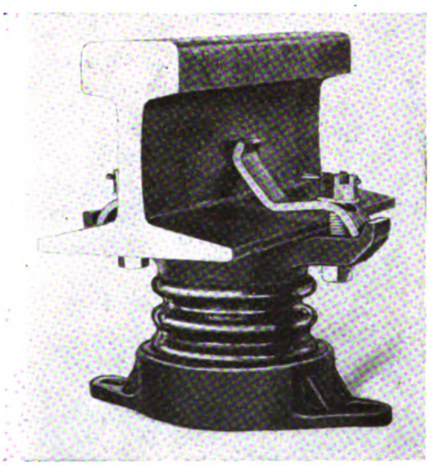
The heating units are of the cast-in sheath-wire type, and one unit is used in each pot, dissipating 750 watts in one rating and 1,000 watts in the other. The leads of the unit are brought over the top of the pot into a connection box fixed to the unit itself.

The maximum melting temperature of this pot is 950 deg. F., and it has a capacity of 30 lb. for 50/50 solder, 40 lb. for lead, 37 lb. for babbitt and 27 lb. for tin.

Third Rail Insulator

A THIRD rail insulator unit of new design has been developed by the Railway & Industrial Engineering Co., Greensburg, Pa. The unit is built up from the Type T support with die-cast metal threaded bands for connecting the hardware to the porcelain.

This method of construction, it is claimed, has a distinct advantage in that the intimate bond produced by die-cast metal exerts an even pressure on the porcelain and resists the vibration existing in craneways and railway beds.

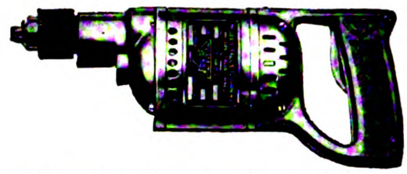


Third Rail Insulator Manufactured by the Railway & Industrial Engineering Co.

Portable Electric Drill

A NEW ¼-in. portable electric drill designated as No. 414, has recently been developed by the Millers Falls Co., Millers Falls, Mass. This drill is operated by a universal motor that can be furnished for either 110 or 220 volts, alternating or direct current. The motor speed is 1,800 r.p.m. at no-load and the capacity of the drill, which weighs 5½ lb., is said to be ¼ in. in steel, 5/16 in. in cast iron, and ⅜ in. in wood.

The pigtail brushes can easily be replaced without taking the tool apart. An armored attachment plug is connected to 8 ft. of high-grade rubber-covered cord and an automatic switch which is mounted in the handle of the drill controls the motor, whose armature turns on ball bearings. The drill is fitted with a Jacobs heavy-duty chuck, heat-treated alloy steel gears, and a ball thrust bearing on the spindle.



Millers Falls ¼-in. portable electric drill

Uni-Pull Belt Drive

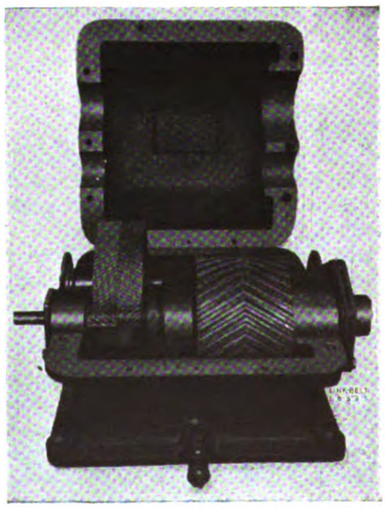
ANNOUNCEMENT has been made by the Rockwood Manufacturing Co., Indianapolis, Ind., of the Uni-Pull as its latest development in belt drives. It is claimed that this drive gives a marked improvement in operating efficiency over fixed-center belt drives, that it is particularly well adapted to close pulley centers, and that the drive operates at all times with uniform tension, uniform pull, and uniform speed.

Briefly, the Uni-Pull drive consists of a Rockwood pulley and a motor, so mounted that gravity, due to the weight of the motor, maintains the belt under a predetermined tension to meet the power requirements of the installation. This unit is shown driving a hammer mill on page 446. In tests conducted by the manufacturer, belts are being run at centers so close that the pulleys almost touch; in one installation an ordinary lead pencil could not be inserted between the pulleys, it is stated.

Herringbone Speed Reducer

DEVELOPMENT of a new line of herringbone speed reducers has been announced by the Link-Belt Co., 300 W. Pershing Road, Chicago, Ill. These reducers are made in three types and a variety of sizes and ratings. All gears are generated by the Sykes method which gives a continuous herringbone tooth.

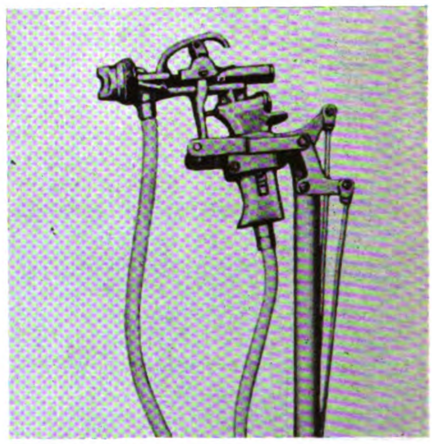
Type D Heavy-Duty, Double-Reduction Link-Belt Speed Reducer with Sykes Herringbone Gears



The Type S reducer is a single-reduction, heavy-duty unit made in ratios up to 10:1 and the various sizes rated to deliver from 0.0252 to 2.77 hp. per revolution of the low-speed shaft. Type D is a double-reduction, heavy-duty unit made in ratios from 10:1 up to 80:1, with a low-speed output from 0.30 to 4 hp. per revolution. The type D unit is shown in an accompanying illustration. Type DS is a double-reduction unit designed for light service; this unit may be obtained in ratios from 11:1 up to 130:1 and rated to give 0.06 to 0.24 hp. per revolution on the low-speed shaft.

Paint Spray Equipment

A PAINT spray gun handle has been developed by the Alexander Milburn Co., Baltimore, Md. Use of this handle facilities the painting of ceilings, high walls, ship sides, tanks, freight cars, and other high surfaces. The handle grips the standard Milburn gun, which, while in use, can be swiveled to any desired angle, it is stated.



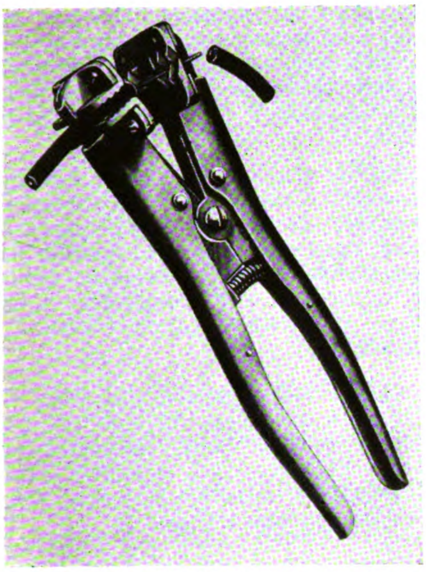
Milburn Spray Gun Extension Handle

The extension is ordinarily 8 ft. in length, although any size can be furnished. A slight pull on the operating handle of the extension simultaneously operates both the air and paint valves on the spray gun.

Wire Stripper

MARKETING of the E-Z wire stripper has been announced by the Pyramid Products Co., 2311 South State St., Chicago, Ill. This device, which is shown in the accompanying illustration, is hand-operated and is adaptable for use on any size of wire from 10 to 20 gage.

It is operated in the same way as a pair of pliers and will strip from ⅛ to 1 in. of insulation at a time. V-shaped notches guide the wire. The insulation is cut and removed in one opera-



E-Z Wire Stripper Manufactured by Pyramid Products Co.

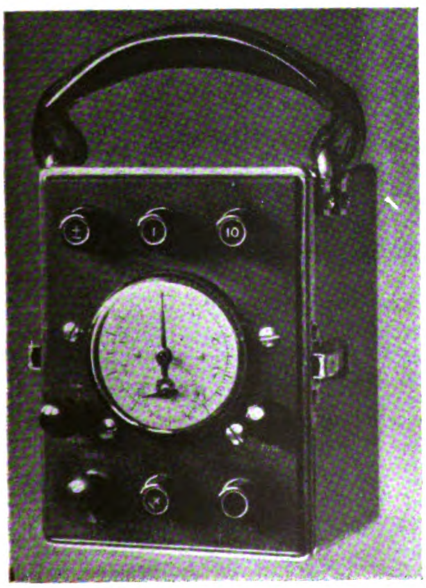
tion of the tool. It is claimed that the insulation can be removed from 1 ft. of wire in less than a minute. It is also said that when used properly there is no danger of nicking the wire when removing the insulation.

Portable Watt-Hour Meter

A NEW Type OB portable standard watt-hour meter has recently been placed on the market by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Several advantages are claimed for the new meter, the outstanding one being the compensation for temperature errors at both unity power factor and low power factor. This compensation is claimed to be inherently permanent for both the electromagnets and the permanent magnets and does not depend on the movement of mechanical parts with the variation in temperature.

New Westinghouse Portable Standard Watt-Hour Meter



The accuracy and the decrease in size and weight of this meter are also important features. The micrometer adjustments have been simplified and the electromagnets are of the one-piece OB type. A zero reset is provided by which both pointers can be set on zero. Potential settings are changed by means of a small switch, and three current binding posts are used, so that the meter may be connected for either 1 or 10 amp. capacity.

Motor and Generator Brushes

A NEW metal and semi-metal brush material has recently been put on the market by the Keystone Carbon Co., Emporium, Pa. This metal brush material is said to be a composition of pure copper and graphite obtainable in a very wide range of proportions, which makes it available for all metal brush applications from the largest rotary converter to the smallest motors.

It is also stated that a method has been perfected by which all shunts are inserted into and processed with the raw material, and thus become an integral part of the brush.

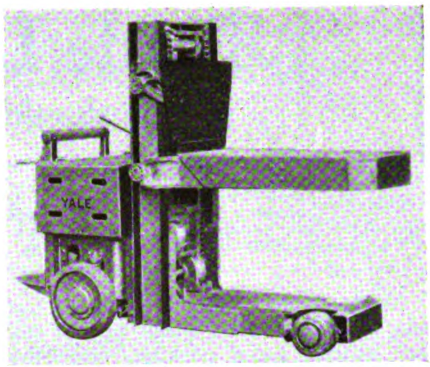
High-Lift Truck

THE Yale Model K25, three-ton high-lift, elevating truck has been added to the line of the Yale & Towne Manufacturing Co., Stamford, Conn. The backbone of the framework consists of a ½-in. thick gusset plate, which extends from the forward end of the truck to the small trailing wheels. The upright channels or platform roller guides are attached to this gusset plate by ¾-in. rivets and strips of steel welded to both sides of the vertical channels to form a pocket or guide.

The elevating platform is raised and lowered through a 1½-in. Diamond roller chain, passing over a power-driven sprocket at the bottom and an idler sprocket at the top. Hyatt heavy-duty roller bearings are employed in the idler sprocket and the shifts of the lower sheaves run in a bath of oil, which also serves to lubricate the spur-gear reduction unit. The two ends of the roller chain are attached to the platform through a spring take-up device, which will automatically adjust itself as the chain wears.

The hoisting motor is connected to the spur-gear pinion through a spring ratchet, so arranged that a positive drive is obtained when raising the elevating platform. A speed of 7½ ft. per minute is obtained when lifting a full load, and a speed of 19 ft. per minute when raising the empty platform. The lowering speed is 19 ft. per minute, loaded or empty.

The elevating platform of the truck is supported in the horizontal position by four rollers, bearing on the inside of the flanges of the vertical ship channels. Hyatt heavy-duty roller bearings are used in this case and a hardened steel thrust washer takes whatever end thrust may occur when lifting loads that



Three-Ton, Type K25, High-Lift Truck Made by the Yale & Towne Manufacturing Co.

are not placed on the center line of the platform.

The platform members are heavy steel castings, having large diameter bosses to support the platform roller pins. The platform has an over-all width of 27 in., a height of 11 in. and a length of 54 in. A four-wheel steering arrangement allows a turning radius of 96 in. at the outside edge of the truck.

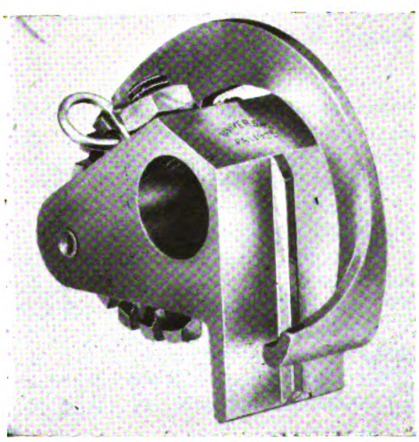
Commutator Brush Holder

ANNOUNCEMENT has been made by the Electric Accessories Co., 310 York Ave., Philadelphia, Pa., of its universal full-reaction brush holders for carbon brushes. It is claimed that this reaction-type holder, in addition to its advantages in commutation, allows a latitude in the width and thickness of bushes that permits the use of one type of brush on several motors.

As may be noted from the accompanying illustration, the design of the holder prevents the brushes from moving sideways on uneven commutators or shifting or moving in the holder due to side oscillation of the armature. It also prevents the brushes from wearing unevenly.

The fact that there is no guard around the brushes will, it is claimed, minimize the likelihood of the brushes sticking or wedging. These holders are made in five sizes. Special mountings can be furnished for adapting the holders to various types of machines.

Universal Full-Reaction Brush Holders



Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

MECHANICAL RUBBER GOODS — Catalog 20 covers the Pioneer line of rubber belting, hose, packing, and other kinds of mechanical rubber goods.—Pioneer Rubber Mills, 345-53 Sacramento St., San Francisco, Calif.

ROLLER CHAIN—A folder illustrates and discusses the application of Diamond roller chain in power transmission.—The Diamond Chain & Mfg. Co., Indianapolis, Ind.

DRAG SCRAPER—Booklet 666 describes, gives specifications, and illustrates a number of applications of the Link-Belt Power Hoe (an improved drag scraper) for handling coal and other loose materials around industrial plants.—Link-Belt Co., 910 So. Michigan Ave., Chicago, Ill.

ELEVATORS AND CONVEYORS—Book 575 devotes 96 pages to a description and illustrations of applications of various types of Link-Belt elevators and conveyors.—Link-Belt Co., 910 So. Michigan Ave., Chicago, Ill.

SYNCHRONOUS MOTORS—Circular 500 discusses the flywheel effect recommendations for ammonia and carbon-dioxide compressors based on the use of the Ideal synchronous motor drive with flywheel-tpye rotors.—The Ideal Electric & Manufacturing Co., Mansfield, Ohio.

UNIT HEATERS — Bulletin entitled. "Cost of Heating and Ventilating Goes Down," describes the Bailey Thermo-Unit for heating and ventilating industrial plants.—Bailey Mfg. Co., Milwaukee, Wis.

BLOWERS AND EXHAUSTERS—Catalog 110 describes the motor and pulley driven types of Uniblade blowers and exhausters for constant and variable speed operation. — Autovent Fan & Blower Co., 730-738 W. Monroe St.. Chicago, Ill.

GROUNDOMETERS — Bulletin 77 describes a portable meter designed for measuring the resistance of ground electrodes. This is made in three types.—Groundulet Co., Newark, N. J.

BEARING METAL—A revised edition of the Magnolia Metal Bearing Book contains 96 pages of practical data, suggestions and instructions on the selection and preparation of bearing metal for various industrial services. This book is illustrated with several sketches showing improved methods of arranging shells for babbitting, the proper proportioning and clearances of bearings, and various arrangements of oil grooves.—Magnolia Metal Co., 75 West St., New York, N. Y.

SLEEVING — A card carries samples and quotes prices on various types of M-R varnish - saturated sleeving.—Mitchell-Rand Mfg. Co., 18 Vesey St., New York, N. Y.

GEARS—A circular illustrates and describes the addition of a line of cast and cut-tooth gears and speed reducers. —Gear Division, Stephens-Adamson Mfg. Co., Aurora, Ill.

FIBER PULLEYS — Circulars describe the line of compressed spruce fiber pulleys and give dimensions and prices of units carried in stock. — Compressed Spruce Products Co., Inc., West Orange, N. J.

SPEED REDUCERS—Catalog 99 covers the line of D. O. James speed reducers and cut gears together with over 50 pages of general engineering data.—D. O. James Mfg. Co., 1114 W. Monroe St., Chicago, Ill.

MATERIAL-HANDLING EQUIPMENT—A booklet entitled, "Jacklift and Stacker Practice," illustrates the numerous applications of the Lewis-Shepard handlift truck and the stacking or tiering machine.—Lewis-Shepard Co., Watertown Station, Boston, Mass.

TEMPERATURE REGULATORS — A 52-page catalog describes the various types of Powers temperature regulators, their application to shop and office, the fuel-saving advantages claimed, and describes a number of installations.—The Powers Regulator Co., 2720 Greenview Ave., Chicago, Ill.

HERRINGBONE GEARS — Bulletin B illustrates and describes a number of interesting applications of Fawcus cut-tooth herringbone gears and pinions.—Fawcus Machine Co., Pittsburgh, Pa.

UNIT HEATERS — Catalog 466 discusses the methods recommended for industrial heating by the use of the various types of Buffalo unit heaters.—Buffalo Forge Co., Buffalo, N. Y.

SHOCK ABSORBER—A recent bulletin illustrates the construction and describes the new Thompson Shock Absorber for use in connection with lighting equipment in industrial plants to prevent lamp spoilage from vibration. This unit has only four parts and may be used in connection with the Thompson Lowering Hanger or alone.—The Thompson Electric Co., 1438 W. Ninth St., Cleveland, Ohio.

SILENT CHAIN—"A Chain of Testimonials," is the title of a booklet issued recently. It contains interesting personal reports from men responsible for the efficient operation of plant equipment, together with photographs of the drives in question.—Morse Chain Co., Ithaca, N. Y.

SAFETY SWITCHES —Catalog No. 17 illustrates the complete line of TV safety switches with accompanying tables of sizes and capacities.—The Trumbull-Vanderpoel Electric Mfg. Co., Inc., Bantam, Conn.

ELECTRIC FURNACES—A circular illustrates the operation of the Ajax-Northrup metal-melting furnaces.—Ajax Electrothermic Corp., Trenton, N. J.

POWER TRANSMISSION — A recent issue of *The Labor Saver*, distributed monthly by this company, describes the construction and operation, illustrates applications, and gives engineering data on the JFS variable speed transmission and the S-A Speeducer spur-gear speed reducer.—Stephens-Adamson Mfg. Co., Aurora, Ill.

GEARS —A new publication, circular 1579-E, contains the latest authentic data and technical information relative to the manufacture, design and construction of Micarta gears and pinions.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ARC WELDING —"Modern Manufacturing With A Stable Arc Welder" is the title of a 36-page booklet recently issued. This booklet outlines briefly the theory of the use of arc welding in production manufacturing. — The Lincoln Electric Co., Cleveland, Ohio.

CHAINS —The fourth edition of the AHSC Catalog contains 60 pages of data on the design, application, and lubrication of high-speed chains.—American High Speed Chain Co., Indianapolis, Ind.

SWITCHING EQUIPMENT —A 48-page bulletin No. 32-C, has been issued, illustrating and describing the high-tension switching and protective equipment manufactured by this company.—The Delta-Star Electric Co., Chicago, Ill.

GEARS—Catalog 47 lists the complete line of Boston gears together with charts and diagrams of value to the gear user.—Boston Gear Works Sales Co.. Norfolk Downs, Quincy, Mass.

BALL BEARINGS—A series of loose-leaf pages give the revised dimensions and load ratings of SKF products.—SKF Industries, Inc., 40 E. Thirty-fourth St., New York, N. Y.

Volume 85 *Number* 11

INDUSTRIAL ENGINEERING

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

Application and Operation of Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

G. A. VAN BRUNT, *Editor*

Contents

Departments

"There is More in This Issue"

The importance of the Services to Production to which this publication is devoted is becoming more clearly recognized with the stiffening of competition. "Keep the plant fit for profits" is the slogan of the plant engineers, chief electricians, master mechanics, handling engineers and others who look to Industrial Engineering to provide them with practical experience, technical information and cost cutting ideas.

In developing an editorial program designed to adequately serve these Production Services, both electrical and mechanical, our editors have felt the need of expanding the number of topics presented in each issue. A beginning has been made in this one in which the number of principal articles has been increased fifty per cent over the usual average. Careful condensation has made this possible, for it is usually possible, though not as easy, to express in three pages what ordinarily would require four.

This is the beginning of a carefully studied plan of increased editorial service which will progress month by month to keep pace with the increasing needs and problems of the Services to Production.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

WASHINGTON, National Press Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4

Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

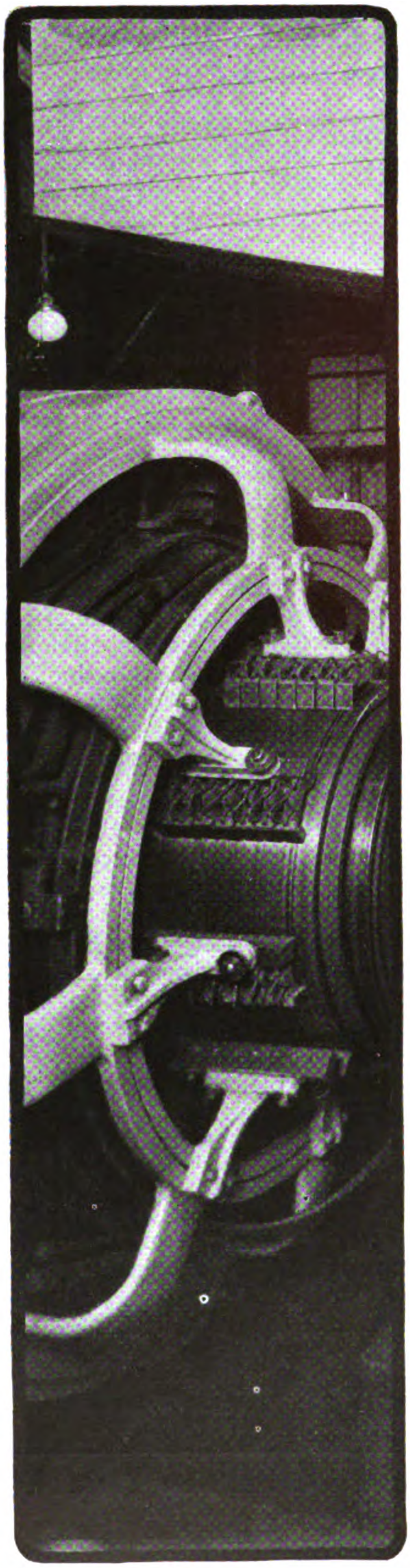
NEW YORK District Office, 285 Madison Ave.
Cable Address: "Machinist, N. Y."

Publishers of

Engineering News-Record	American Machinist
Power	Chemical and Metallurgical Engineering
Coal Age	Engineering and Mining Journal
Coal Age News	Electrical Merchandising
Ingeniería Internacional	Electric Railway Journal
Bus Transportation	Construction Methods
Electrical World	Radio Retailing
Industrial Engineering	Electrical West *(Published in San Francisco)*

American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.



INDUSTRIAL ENGINEERING

Application and Operation of
Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

Volume 85 NEW YORK, NOVEMBER, 1927 *Number 11*

The Men Who Keep Industry Fit to Fight

...Gene Tunney went down in the seventh round in the late Chicago fistic combat under a shower of blows that would have put anyone else to sleep for an indefinite period. But he had something in his possession that enabled him to come back and win the battle. That vital something was perfect condition.

...Every athlete knows that when skill or ability are evenly matched, condition is the deciding factor. When the critical moment comes, the muscles, nerves and vital organs of the real champion play their parts with unconscious effort, leaving the brain free to plan the winning strategy.

...There is a good deal of similarity, and some differences, between the physical encounter of two ring champions, and the economic battle waged by industrial plants.

...The industrial struggle is harder than the meeting of the padded gloves. There is no rest between rounds, no cheering crowds to inspire the fighters to increased effort. Moreover, the training or conditioning of the industrial plant must be done while the battle is going on. And it must go on day after day, year after year unceasingly or until the plant is counted out by the tap-tap-tap of the auctioneer's hammer.

...Yet there is great joy in the battle for those who participate in it—great responsibility and opportunity for you who are responsible for keeping our industrial plants in fighting trim.

...The champion athlete must have perfect muscular and nervous co-ordination; the ability to concentrate his vital powers immediately. The fighting industrial plant must maintain perfect co-ordination of its electrical and mechanical power transmission systems; its motors and driving mechanisms which form the nerves and muscles of the industrial world. It is a big job to choose the right members; to install them properly in the fighting plant; to keep them fit or to replace them with better or bigger ones when the need occurs.

...The champion athlete must have reserves to call upon when the pinch comes. It is a big job to maintain adequate reserves throughout your plant, and to guard continually so that no weak or neglected element may cause unforseen shutdown. For a one-hour shutdown in your plant means a two-hour gain in production by your competitors.

...How absurd it would be to expect a man with stiff muscles and hardening of the arteries to compete successfully in a physical contest. Is it not equally absurd to expect the industrial plant to survive the struggle handicapped by poor lubrication and with its traffic arteries clogged through inferior methods of materials handling?

...Competition during the coming months will be of increased intensity. More than ever will plant condition be of vital importance to profit making and survival. You men of the Services to Production, you plant engineers, electrical and maintenance chiefs, you master mechanics and materials handling engineers have a big job ahead of you. More power to you, and more power to industry through you!

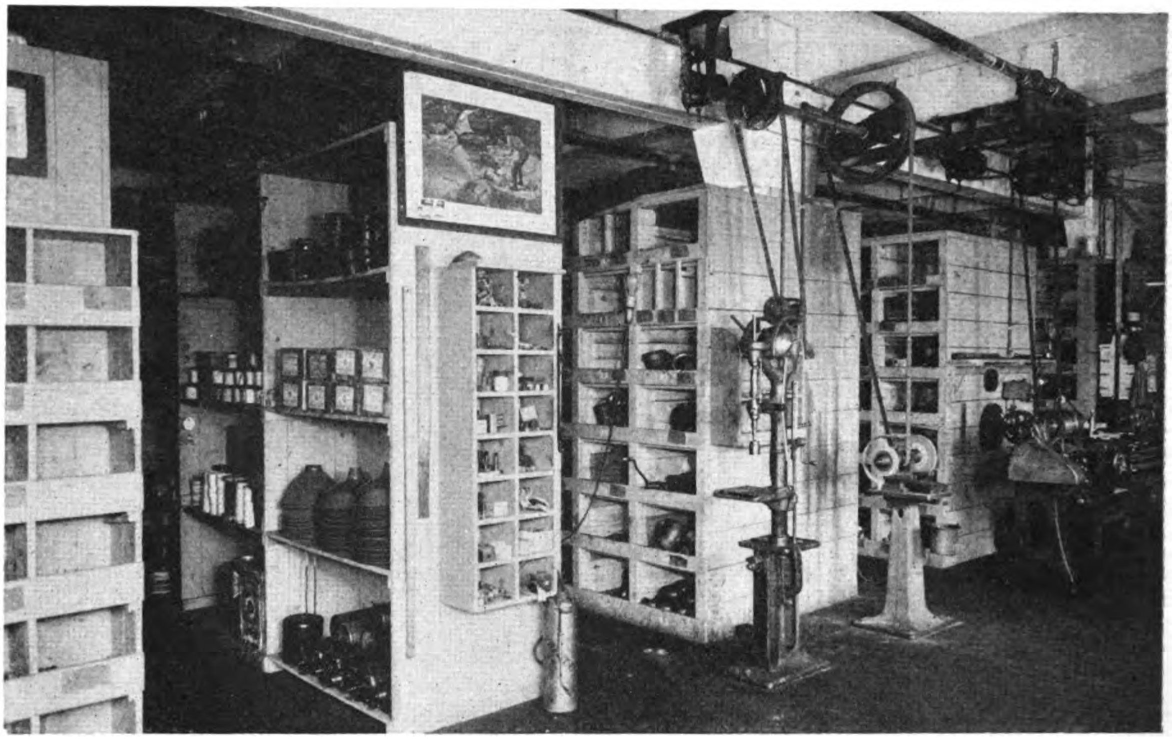


Fig. 1—Storeroom for maintenance supplies used by the electrical and pipe departments only.

Handling Maintenance Supplies

in the Simmons Company plant

By M. J. SCHMITT
Chief Engineer
Simmons Company, Kenosha, Wis.

THE amount of routine involved in handling and disbursing materials and supplies for maintenance and new construction in an industrial plant is determined to a large extent by the amount, kind, and value of the supplies handled, the frequency of withdrawal, the organization of the department, and the urgency of maintaining uninterrupted production. Modern industrial production demands practically uninterrupted operation, which necessitates stores or supplies adequate to fill any demand for replacement or renewal of broken or worn parts, or other maintenance work, and an arrangement of such supplies which permits quick location and easy access for filling requisitions.

One of the questions always up for discussion in connection with the handling of maintenance stores and supplies is whether such stores should be included with the general plant stores or whether a separate storeroom is advisable. In our case separate stores are provided for the electrical, the mechanical, and the building maintenance departments. Perhaps the principal advantages of having separate stores are that the supplies are located near the department using them, and to fill each requisition does not require a trip to the general stores.

In addition, these stores are accessible to the department at night, on holidays and on Sundays, when the plant and general stores may be closed. It is seldom advisable to permit any except regular storekeepers to have access to a general storeroom. Also, representatives of maintenance departments would not be familiar with the arrangement of supplies in the large, general stores and might have to spend considerable time at night or other times when the storekeeper is away before they found what they wanted.

Before going further into this question of maintenance storekeeping it may be well to describe briefly our organization, because our plan of handling stores is closely tied in with our maintenance activities.

Maintenance at the Kenosha plant of the Simmons Company is taken care of by three departments. Millwright, carpenter and allied work is under the direction of the building superintendent. The machine shop and toolroom are under the supervision of the master mechanic. The electrical and pipefitting work and power department are under my direction. Each of these divisions has control of its own stores. These separate maintenance stores are in reality, however, branchs or departmental subdivisions of the general stores. The method of handling these stores in the three departments varies slightly, but in general all three fol-

low about the same plan of organization and operation. Therefore, only the methods followed in the electrical and pipe departments will be described here.

The shops and headquarters of the electrical and pipe departments are located adjoining each other, which simplifies supervision and also makes it possible to use one storeroom as in Fig. 1, and one combination clerk and storekeeper.

The staff of the electrical department is composed of one foreman, two wiremen, one motor inspector, one day trouble man, one armature winder, who also inspects and repairs controllers on elevators, one night trouble man, one day trouble and repair man in the rolling mill, and one clerk who also serves as storekeeper.

The pipe department has one foreman, six pipefitters, one shopman, one day and one night trouble man, one heat man who takes care of pumps and steam traps in the winter and one night heat man.

Incidentally, in the same section of the building are the headquarters for the plant fire department which is made up of men from the electrical and pipe departments. Generally, several of these men, enough to answer fire calls, are in or close to the departmental shops at all times. The night electrical and pipe trouble men are also members of the night fire department.

The plant is engaged in the manufacture of metal beds, metal furniture, springs, and mattresses. Approximately 900 motors, ranging from 3 hp. to 750 hp. in rating are installed in the plant. About 450 of these motors, including the fractional-horsepower sizes, are below 3-hp. rating. The largest motors, however, are used to drive equipment in the rolling mill. Practically all the motors with the exception of some fractional-horsepower units operate on 440-volt, 60-cycle, three-phase a.c. circuits. Some of the fractional horsepower motors are operated on 110-volt, single-phase a.c. circuits and others on 110-volt, direct-current lines. Two motor-generator sets supply power for the direct-current cranes, switch operation, electrical stops on important machinery, and some other uses. Synchronous condensers are used for power-factor correction.

Fig. 2—Storage space for surplus equipment, spare motors and pulleys. Equipment marked × is for sale or disposal. Motors carrying a tag are spare motors for a particular installation. Other motors without tags are spares available for use wherever a motor of that size will fit. Motors are handled in and out of the room by a chain hoist on a monorail trolley.

Because of the comparatively small amount of direct-current equipment, motor repair is a small item. However, we make practically all coils needed for rewinding motors, and transformer coils for special welding machines. It is usually necessary to make the motor coils on special order instead of carrying them in stock. Bearings are made up in the machine shop and any other necessary machine work is done there on requisition. We have drill presses, a lathe, shaper, and pipe-threading machines in our electrical and pipe departments; so we are able to make many of the smaller repairs or make minor repair parts not carried in stock.

As stated previously, our electrical stock, pipe fittings, and supplies for repair, renewal, maintenance, and new construction work are carried in the same storeroom. Storage space for surplus equipment is shown in Fig. 2. A clerk issues stock on requisition from either department, maintains a stores record of receipts and disbursements and, in addition, receives trouble calls for both electrical and pipe trouble men. These calls are entered on large Daily

Fig. 3—This daily trouble report sheet lists all work handled by the trouble man.

The clerk who handles the stockroom also receives all trouble calls which are listed on this report. When the trouble man clears an interruption to service, he reports here the time he returns to the office and the nature of the trouble. These reports are filed for future reference. The abbreviation "ooo" means "out of order."

FORM 1941--1M-3-26
SIMMONS COMPANY
DAILY TROUBLE REPORT 7-18-27 DEP'T ________ 192__

DEPARTMENT	TROUBLE	BLDG.	FLOOR	TIME REPORTED	TIME CLEARED	NATURE OF TROUBLE	REMARKS
Mattress	String lights ooo	39	6	8:35	9:05	OK. Wire grounded, fuse out	
Coil Spring	Motor ooo	38	5	10:10	10:25	Down on bearings, to be taken out	
Steel Tube	#14 Spot Welder ooo	60	1	10:20	11:05	OK. Contacts burnt out in Oil Switch	
Coil Spring	Connect Motor	38	5	11:25	11:40	OK.	
		7-	21	-27			
Steel Tube	#1 Saw Machine ooo	60	1	7:05	7:26	OK. Main fuse out on line	
Stairway	Light ooo	90	1	8:35	8:50	OK Bulbs burnt out	
Mt + Pkg	Spring lights ooo	33	5	10:15	10:35	OK Loose Connection in Switch	
Coil Spring	Lights ooo	38	4	10:45	11:15	OK Shell on Socket broke.	

Trouble Reports listing the department, the nature of the trouble reported, the building, floor, and time reported. One of the trouble report forms for the electrical department is reproduced as Fig. 3. The form used by the pipe department is quite similar. The symbol "ooo" on this report is an abbreviation for "out of order."

If the trouble man is in the office he goes immediately to clear the trouble. If the call indicates the interruption of work in any step in the process or that it is holding up a large number of men, the armature winder or any other electrician who may be in the department is sent out. These men are so familiar with the work in the different departments that they usually know from the nature of the call what supplies to take. Incidentally, they make up various assemblies of supplies which enable them to clear troubles more quickly.

After clearing a case of trouble the men return to the office and make a report showing the time that they return, the nature of the trouble, and such information as they can give about the cause of other conditions.

These report sheets when filled are sent in to my office for study and are then filed. At the end of the day the trouble man makes out his Time Ticket, Fig. 4, from the trouble report, and enters on it any material used. A separate time ticket is made for each department against which work and material are to be charged. When several calls are made to one department in a day, the totals are grouped on a single time ticket.

Material Records, Fig. 5, are kept on all materials carried in our stockroom. The practice of entering each item as distributed is followed in connection with the operation of some stores departments. Because much of the material and supplies is issued in small quantities of one, or at most a few units, at a time to the trouble men, that task of entering the disbursements on the card for each issue of supplies would fill the card in a short time and entail a large amount of clerical work. Instead, when the weekly Report of Stores Used, Fig. 6 is filled out, the clerk quickly totals the amount of each item disbursed and enters this weekly total on the Material Record, Fig. 5 shown on this page.

SIMMONS COMPANY
ELECTRIC DEPT.
TIME SLIP

EMPLOYEE ____________
CLOCK NO ____________ RATE ____________
CHARGE ____________ DEPARTMENT ____________
EXPENSE NO ____________ JOB NO ____________
COMMENCED ____________
FINISHED ____________
OVERTIME ____________
TOTAL TIME ____________ HOURS ____________ MIN.
AMOUNT OF LABOR ____________

IMPORTANT
MATERIAL USED ON THIS JOB MUST BE ENTERED ON THE OTHER SIDE OF THIS SLIP.

Fig. 4—Workers in the electrical department report their time on this slip.
For example, at the end of the day the trouble man makes out a record of his time, charging the work he has done to the various departments and also entering the material used on the back of the slip. The same is done by other workers in this department.

The material used is reported to the general stores department weekly on the Report of Stores Used Sheet, Fig. 6. This report shows the quantity of each item used, the department to which it is to be charged, the name or description of the article, and the account or job number to which the supplies are to be charged. Pricing is done by the stores department and the costs distributed by the accounting department.

We do not keep a running balance on the Material Record card. Our amount of stock and the number of items is so small that the clerk can easily tell by observation when the stock of any item gets low. If, for any reason, a balance is wanted it may be taken from the cards in a moment. This practice, I realize, could not be followed in a stores department handling large quantities and varieties of material, or where responsibility could be placed on more than one man. However, these are only branch or departmental stores. The principal inventory records are maintained by the general stores department, whereas our departmental stores records are maintained more for our own convenience and do not need to be so complete.

Ordinarily, we try to keep our inventories low. Whenever we know that a special new construction or rearrangement order is coming through the material necessary is ordered through the general stores department, which charges it to our electrical stores, if one is issued. Then, when the material is used, it is charged against the job number on

Figs. 5 and 6—A card record is kept of each class of material on hand and a weekly report made of material used.
A separate card is used for each item of stock. All of the receipts are entered at the right and disbursements entered weekly at the left. Each week the clerk makes up this Report of Stores Used in the electrical department and shows the quantity and department or account to which it should be charged. The totals of each of the materials are entered on the proper Material Record card.

SIMMONS COMPANY
MATERIAL RECORD

MATERIAL No. 14 R.C Wire INV. 250

12-18	881	3-18	856	12-3	2500
12-25	726	3-25	450	12-13	2500
1-8	778	3-31	1070	1-24	10000
1-15	338	4-8	524	4-4	10000
1-22	1678	4-22	598	5-31	5000
1-28	973	4-29	324	7-2	10 000
2-4	532	5-6	276		
2-11	502	5-13	554		
2-15	314	5-22	7163		
2-18	70	6-3	425		
2-25	610	6-10	454		
3-4	620	6-24	280		
3-11	178	7-15	544		

SIMMONS COMPANY
REPORT OF STORES USED No. 100
Electric DEPT.
WEEK ENDED 7-22 1927

INSTRUCTIONS—
[illegible] FACTORY SERVICE DEPTS. [illegible]

QUANTITY	CHARGE S.O. OR A/C NO.	CHARGE DEPT. NO.	ARTICLE	UNIT	PRICE	VALUE
12	206	24	60 w. Globes			
6	206	17	150 w. "			
1	Bayonne	7-14-26	R #30965 - M.S. 20 amps switch			
30 ft	303	35	½" Conduit			
2	206	Street	150 w. Globe			
1	"	"	½ x ¾ 3 hole Pole Corner			
1	306	66	#5614 Hunter chain Fixture			
1	"	66	300 w Globe			

FOREMAN'S O. K. [illegible]

the Weekly Report of Stores Used, Fig. 6. Requisitions on general stores for ordering special supplies are issued from my office in the form of memorandums. Ordering stock for replenishment is handled automatically through my office.

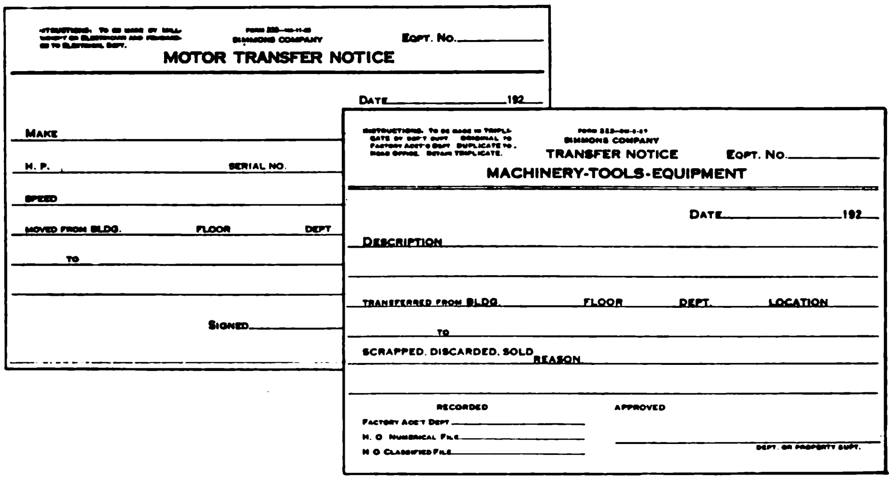
When not answering calls, the night pipe trouble man makes pipe nipples which are turned over to the clerk who counts and checks them into stock in the same manner that other material received is handled. This man also cuts and threads pipe and does much other useful work on new construction jobs for the next day. The night electrical trouble man also gets electrical work which must be done in the shop, ready for the next day. Both of these men have access to our storerooms at night. The maintenance storeroom and repair shop Fig. 7, are in the same section, wherein, equipment for bending and threading conduit and an electrically-heated armature and coil baking oven are located.

We also keep our own motor and control record which is filed by buildings and subdivided by floors. Thus, whenever a motor is reported down, the trouble man can check the size and other information on the motor and control before going to the job, and so be more likely to take the necessary supplies with him.

Whenever a motor is moved, the millwright or electrician handling the job reports this to the electrical department on the Motor Transfer Notice, Fig. 8. This transfer is reported to the accounting department and head office on the Machinery-Tools-Equipment Transfer Notice, Fig. 9. This latter notice is used in connection with the inventory and depreciation record which is kept according to the Simmons Equipment No. in the upper right hand corner of this report. For this reason every machine carries a brass tag which has its Simmons No. on it.

Convenience and accessibility to stores and supplies, with as little routine and clerical work as necessary are, we believe, the essential elements in connection with maintenance stores. The method we use is very satisfactory, is tied in carefully with the organization and operation of the department, and incurs only the amount of routine necessary to keep the stores in order and to know what we have on hand.

Fig. 7—Supplies of wire and conduit are also carried in the storeroom.
The maintenance storeroom and the repair shop are in the same section. Equipment for bending conduit is shown on the bench in the foreground. An electrically-heated armature and coil baking oven is located in the background at the right.



SIMMONS COMPANY EQPT. NO.
MOTOR TRANSFER NOTICE
DATE 192
MAKE
H. P. SERIAL NO.
SPEED
MOVED FROM BLDG. FLOOR DEPT
TO
SIGNED

SIMMONS COMPANY
TRANSFER NOTICE EQPT. NO.
MACHINERY-TOOLS-EQUIPMENT
DATE 192
DESCRIPTION
TRANSFERRED FROM BLDG. FLOOR DEPT. LOCATION
TO
SCRAPPED. DISCARDED. SOLD REASON
RECORDED APPROVED
FACTORY ACC'T DEPT.
H. O. NUMERICAL FILE
H. O. CLASSIFIED FILE
DEPT. OR PROPERTY SUPT.

Figs. 8 and 9—Transfers of equipment are recorded on these notices.
Whenever a motor is moved, it is reported to the electrical department on the form shown at the left. The head of the electrical department then reports this transfer on the Machinery-Tools-Equipment Transfer Notice at the right, so that the main office is able to keep account of all machinery or equipment charged against the various departments.

Announcing the National Power Show

THE Sixth National Exposition of Power and Mechanical Engineering will be held at Grand Central Palace, New York, N. Y., from Dec. 5 to 10, inclusive. The annual meetings of the American Society of Mechanical Engineers, and the American Society of Refrigerating Engineers, as well as numerous other organizations will be held at the same time as the exposition; some of these will meet jointly with, or in bodies, attend the exposition.

It is expected there will be numerous exhibits of materials handling equipment, transmission equipment, and mechanical exhibits of all kinds, which will lead the way to the complete equipment of every industrial plant.

The managers report that the exposition will this year occupy four full floors of the Grand Central Palace and that excepting a few spaces still available all space is engaged. All inquiries should be addressed to the International Exposition Company at the Grand Central Palace, New York, N. Y.

Applying SAFETY To Plant Operation

THE sixteenth annual Safety Congress which was held at the Stevens Hotel, Chicago, Sept. 26-30, under the auspices of the National Safety Council drew an interested attendance of approximately 5.000 people.

The principal officers of the National Safety Council for the coming year are as follows: President of the council, H. E. Niesz, Commonwealth Edison Co., Chicago; treasurer, T. G. Hellmuth, Chicago, North Shore & Milwaukee Railroad Co.; managing director, W. H. Cameron, Chicago; vice-president for industrial safety, E. W. Beck, U. S. Rubber Co.; vice-president for public safety, Miller McClintock, Harvard University; vice-president for engineering, G. E. Sanford, General Electric Co.; and vice-president for health, Prof. C. E. A. Winslow, of Yale University.

The good work which has been accomplished in accident prevention is indicated by the decrease in industrial accidents in practically all industries. It was stated at this meeting that if all the information and knowledge of unsafe conditions and practices were applied and taken advantage of by every individual interested that practically 90 per cent of the accidents could be eliminated. Organized safety work must be given credit for much of this advancement.

Cost of Accidents

When discussing the cost of accidents, H. W. Heinrich, assistant superintendent, The Travelers Insurance Co., stated that compensation payments (compensation and medical payments) constitute only one-fifth of the total employer accident cost. The incidental cost is estimated at four times the compensation cost.

In the meeting held by the Engineering Section, American Society of Safety Engineers, especial attention was given to the discussion of the reports of the Research Committees on Wire Rope Attachments and Connections, Effect of Annealing on Chains, and Elimination of Harmful Noise. All of these were preliminary reports outlining the tests and other research work which should be made. The chairmen of the various committees urged that safety and operating men give the committees the benefit of their experience. This may be addressed to the respective committees in care of the National Safety Council, 108 E. Ohio Street, Chicago, Ill.

Briefly, the work outlined by these committees is as follows: The Committee on Wire Rope Attachments and Connections plans to make tests of the reliability of the various types of attachments and connections and of the methods of applying them. Particular study is to be given on reliability. The Committee on Elimination of Harmful Noise is studying the effect of noise and endeavoring to determine what noises are the most harmful.

The importance of safety is well understood when it is realized that of approximately 90,000 fatal accidents in the United States during 1926, some 24,000 were among the workers in industrial plants. The number of injured runs into the hundreds of thousands annually.

The Committee on Effects of Annealing Chains is to make a study of annealing at various temperatures to try to determine whether annealing is worth while and, if so, the temperature and treatment which will give the best results. The interesting conclusions of a group of British engineers who were investigating the cause of chain failures was included in the report. This group stated that chain failures resulted from overloading, defects in manufacture, and advanced a theory that the sudden breakage of an apparently good chain was due to a brittleness, or so-called "crystalization," of a thin skin on the surface of the link resulting from the light surface impacts of handling; a small crack in this brittle skin is supposed to be the start of the break. The work of these committees will be watched with much interest.

"In general, the cause of all fires is improper maintenance," was the startling statement of Benjamin Richards, Manager, Underwriters' Service Association, Chicago, Ill. "In most industrial plants the general maintenance or upkeep departments have charge of heating, lighting, arrangement of power drives, and such other features as may include the causes of all, so-called, 'common-hazard fires.'" Mr. Richards then pointed out that with the increase in size of the plant and the complexity of its management, the men who control the expenditures are far removed from the intimate knowledge of the requirements and so it is more difficult to obtain their approval to appropriations for much above the absolute essentials for the proper protection of the plant.

Mr. Richards emphasized the hazard of the modern industrial plant of a single large area under one roof and without division walls containing a wide variety of processes and the resultant special hazards. Especial care must be given to housekeeping, packing and other inflammable material, wood construction and other flame feeding materials in such construction.

Reducing Fire Hazard

In a paper entitled, "Relation of Plant Housekeeping to Fire Hazards," Eugene Arms, Mutual Fire Prevention Bureau, Chicago, Ill., stated that, "cleanliness is all important to fire protection. A match or cigarette thrown on a clean wooden floor will not ignite it. When the fire spreads so rapidly that all exits are cut off, nine times out of ten the cause is bad housekeeping. Plant cleanliness creates careful employees.

Walter C. Wagner, of the Philadelphia Electric Co., Philadelphia, Pa., presented a paper "Prevention of High Voltage Hazards in Industrial Substations." A synopsis of his paper appears on page 525 in this issue of Industrial Engineering.

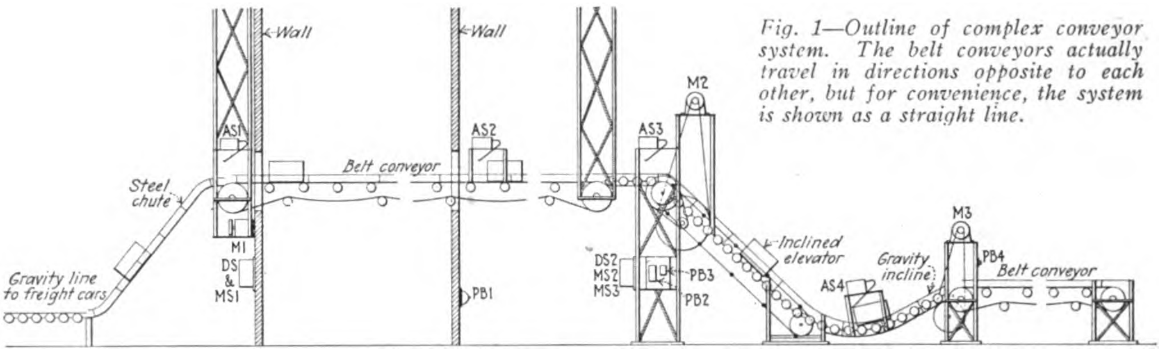


Fig. 1—Outline of complex conveyor system. The belt conveyors actually travel in directions opposite to each other, but for convenience, the system is shown as a straight line.

How a Complex Conveyor System Was Magnetically Controlled

By P. T. VAN BIBBER
Consulting Engineer, Newark, N. J.

THE USE of magnetic switches to control both small and large motors from remote points is becoming more common each year, therefore, it is the purpose of this article to set forth a rather unusual method of making this type of switch serve also as a sort of automatic block-control system on a conveyor installation.

Necessity is usually the real instigator of any novel departure from the regular ways of installing any mechanical or electrical contrivance and such was the case in this installation. The conveyor system, as shown in Fig. 1, was installed to handle empty wooden boxes from the rear of three bottle-washing machines to a line of freight cars on the other side of the building, a total distance of 350 ft.

After a box had been unloaded at any of the machines it was thrown onto the belt conveyor section shown at the right. At the end of this first belt section was an inclined gravity roller section, dropping down to the base of an inclined elevator and at the same time curving around 180 deg., so that this elevator lifted the empty boxes to an elevation of about 12 ft. again and the second section of belt conveyor carried them over the three machines through a a separate process room and into a warehouse for storage, where the boxes were dropped down again by means of an inclined steel chute. From here another section of gravity roller conveyor carried the empty cases across the warehouse, a distance of about 150 ft., to the loading platform where they were again lifted into freight cars by means of a second inclined elevator, for reloading with bottles.

When first installed, the motors driving the two belt conveyors and elevator were fitted with magnetic switches, having ordinary push-button control of the "safe-stop" type, located near each unit so controlled. Before the system had been in operation many hours it became quite evident that an operator would have to be maintained at each motor control if delays were to be avoided. These cases from frequent handling often had broken pieces of the bottom or sides catch on a guard rail support or roller. When this happened the line would be blocked at that point and, if the units just behind the jam were not soon stopped, boxes would be piled on the floor.

The first improvement was to install an automatic stop for each section, as shown on the drawing at *AS1, AS2,* etc. These were made by mounting a standard make of hatchway limit switch above the conveyor line at each point and fastening an inclined arm to each switch of proper length, so that a box would easily pass underneath if in right position but would cause the switch to open if the box came along on end, yet could still pass under without jamming. The first point of trouble was at the end of the curve entering the first elevator, where occasionally a broken side of a box would catch on the guard rail and hold up the line. The first automatic stop switch, therefore, served to stop the motor driving the first belt conveyor section. As soon as the case on end was removed and the limit switch allowed to drop to normal position the belt would immediately start up again.

The next point of trouble was at the top of the elevator, where a box might become up-ended by the conveyor-chain cross bars catching on a broken bottom board. The lifting of the switch arm *AS3* would immediately stop the elevator and, although the gravity section leading to the second belt was only inclined so as to require one box pushing another to reach the belt beyond, the offender went no further until righted and pushed along by hand. About 50 ft. further at the top of the elevator ahead, another stop switch, *AS2,* was installed, in series with the one at the end of this belt section. The long belt line stopped, if either switch was lifted slightly.

The installation of these safety-stop switches, however, only served to shut off the driving power of the section on which each was installed. It did not prevent further jamming up of cases from the units ahead, which continued to run when either the elevator or long belt section stopped. It became evident, therefore, that some automatic means must be provided to also stop the units ahead of where the trouble occurred so, the interlocking system, as shown on the accompanying wiring diagram was developed and put into operation. For the safety of employees, the starting button was located at the ele-

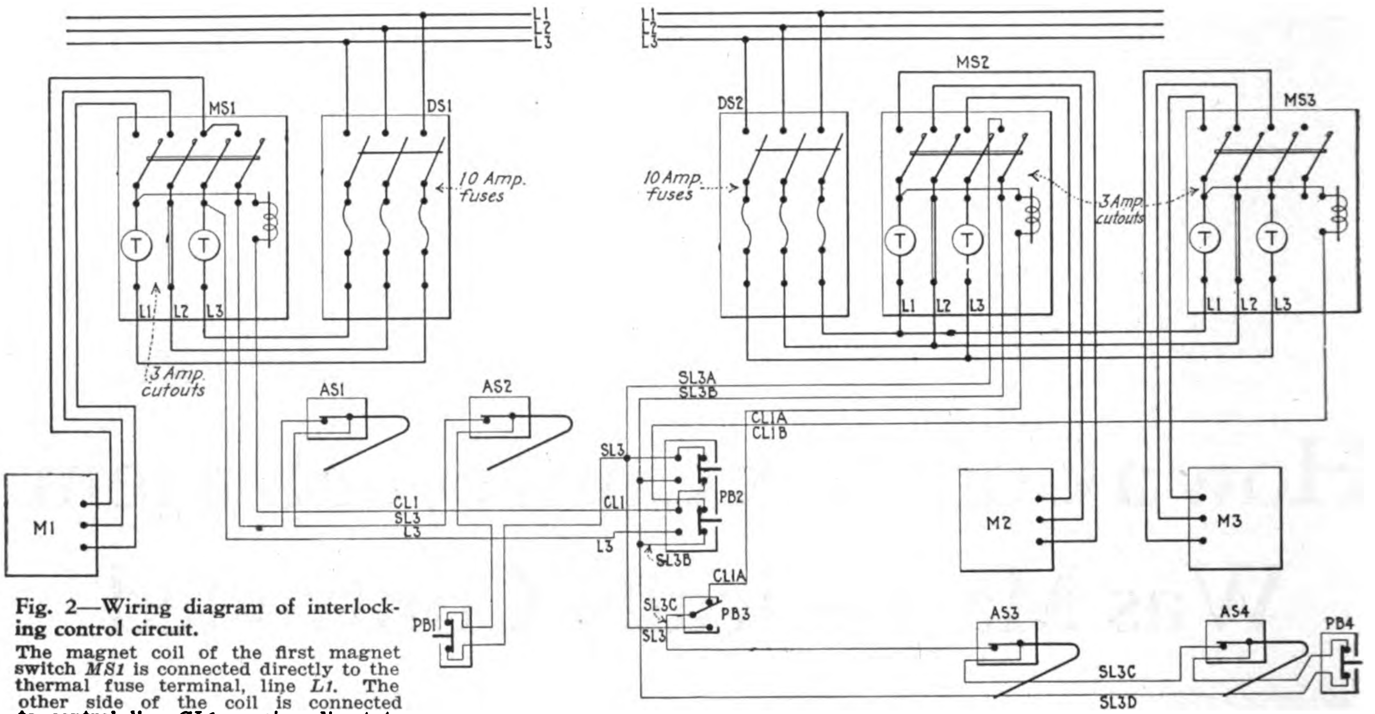


Fig. 2—Wiring diagram of interlocking control circuit.
The magnet coil of the first magnet switch *MS1* is connected directly to the thermal fuse terminal, line *L1*. The other side of the coil is connected **to control line *CL1* running direct to the main pushbutton *PB2*. A second control line *SL3*, is connected to the bottom of the fourth switch blade. When the switch is closed this line is energized from power line *L3* through the thermal fuse.**

vator as indicated by *PB2*. The entire system or any part of it could be started again at any time by only one man, who was responsible for the safety of all others.

In addition to the automatic limit stop switches already mentioned, additional stop buttons were provided, as indicated by *PB1* and by *PB4*. Although no push-button was provided for stopping the system at the warehouse end, this could be effected easily by merely opening the disconnect switch on partition wall, *DS1*, which shuts down the motor from this point; also the control circuit to the two other motors, yet the entire system including this motor could not be started again after this switch had been thrown in except from the start button, *PB2* at the elevator.

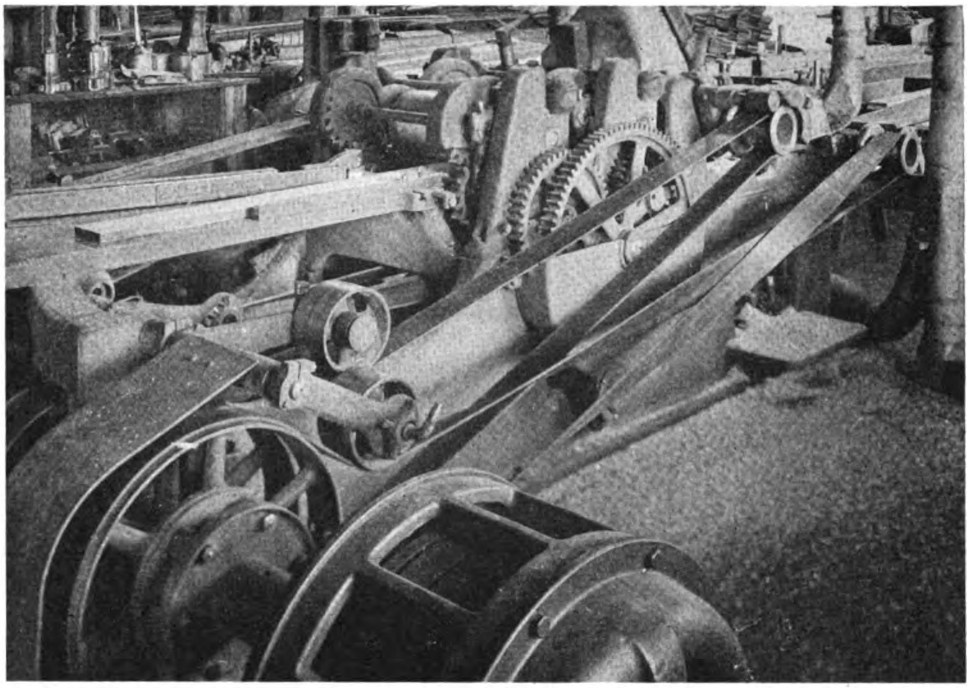
By referring to the wiring diagram Fig. 2, it will be noticed that contrary to the usual practice, the live side of the line comes into the first magnetic switch through the thermal cutout fuses, instead of through the switch blades first. This was done to break the control circuit to the other two motors and thereby stop them should this first motor become overloaded and blow out one of these thermal fuses, thereby stopping the long belt section first. Similarly, the control connections on one side of the magnet coil of the other two switches are also brought through a thermal cutout so that each motor would be stopped immediately if a thermal fuse opened the circuit from an overload, and thereby prevent the motors running single phase for even a short time.

In starting up, the start button of switch *PB2* is first depressed until it makes contact with the two inner points, the disconnect switches all being previously closed. Current from control circuit *L3*, which is always alive, passes to control line *CL1*, energizing magnet coil and switch *MS1* closes. This immediately makes control line *SL3* alive and consequently *SL3A* up to fourth switch point of *MS2*. With starting button still held in, the stop button is now pressed and this causes current from line *SL3* to flow into branch *SL3B* leading to magnet coil of switch *MS2*, through *SL3D*, *SL3C* *PB3* and *CL1A*, thereby causing this switch to close. The stop button is then released, which completes the circuit through its outer points from *SL3* to *CL1* back to coil in switch *MS1*, independent of starting line *L3*, thereby holding this switch closed as long as line *SL3* is unbroken. The start button is now released, which allows the magnet coil of switch *MS3* to be energized through the outer contact points of the button, which tie in the branch control line *CL1B* with *SL3B*; the latter having been energized from *SL3* through lines *SL3A* and *SL3B* by the closing of the fourth switch blade in *MS2*.

Turning to the safety stops, start at the beginning of the conveyor system. Opening any of the switches *AS3*, *AS4* or *PB4* would break the control circuit *SL3C* and *SL3D*, which starts from *SL3B* above the double pushbutton and ends in *PB3*, which is an ordinary key-locking type of standard two-circuit house-lighting switch. With *PB3* in position shown, which leads to magnet coil of *MS2* through line *CL1A*, current would be cut off from this coil, causing switch *MS2* to open and thereby cut off the current in branch line *SL3B*. This in turn renders magnet coil of switch *MS3* inoperative and it immediately opens, yet *MS1* has not been affected and the long belt section driven by motor *M1* would continue to operate. After the cause of stopping had been remedied motors *M2* and *M3* could again be started by going through the same procedure as outlined before in starting up the system, without stopping *M1*, providing care was taken to close the inner circuit of the start button before the stop button was pressed to start up *M2* and *M3*.

Going further along the system, should switches *AS1*, *AS2* or *PB1* be opened, the control line *SL3* would immediately be interrupted. This would stop the current to all three coils at once, through lines *CL1*, *CL1A*, and *SL3A* whose branches lead eventually to coil line *CL1B* of *MS3*. Thus *M1* driving the long belt section cannot be stopped either by the automatic limit switches or the emergency stop button without the other two motors driving the first belt and inclined elevator also stopping, thereby preventing the boxes

(Please turn to page 526)



These belts driving the cutting heads on a wood planer are operated at a speed of about 6,000 f.p.m. Note the fixed idler on the slack strand of the belt, close to the driving pulley. This idler increases the arc of contact on the small pulley and reduces the belt tension required.

Speed and Power

Their Relation in Leather Belt Drives

By ROY C. MOORE
Chief Engineer,
Chas. A. Schieren Co.,
New York, N. Y.

THIS fourth article of the series* on power transmission problems in connection with leather belt drives will begin the discussion of the operating factors concerning the leather belt itself. Previous discussions have analyzed problems arising from, and the effect of, varying center distances, the use of fixed and flexible idlers, and the effect of, pulley diameters. In these discussions the belt has been considered only as an incidental element of the drive.

One of the first questions that arises regarding the belt, and one on which there is considerable misunderstanding, is the effect of speed on its ability to transmit power. Belts, like almost every medium for the mechanical transmission of power, are confined to a certain range of speeds in which they can operate with economy and reliability. Speeds in excess of this range are often the cause of unsatisfactory operation of belts. For general factory use where the belts are of moderate widths, such as those used on general countershafting and machines, speeds between 1,000 and 3,000 f.p.m. have proven to be the most satisfactory. In the case of large main drives where the pulleys are of good size and the bearings are mounted on solid foundations, higher belt speeds, such as 5,000 to 6,000 f.p.m. have proven satisfactory.

An analysis of the maintenance records of the belts in any factory will show that small belts operating at high speeds (in excess of 3,000 f.p.m) require more attention than those operating in the range between 1,000 and 3,000 f.p.m. The better service in the lower range of belt speeds is undoubtedly because:

(1) The belts make fewer bends per minute.

(2) The pulleys remain in proper alignment for longer periods of time, as vibration at low speeds is less.

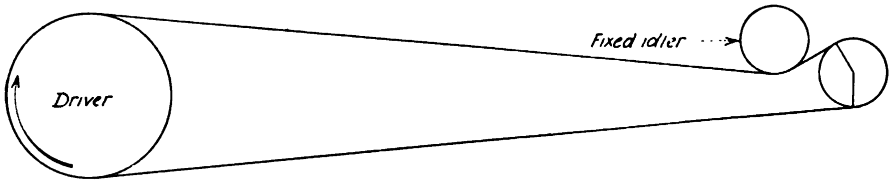
(3) The belts can correct misalignment more easily at the slower speed than at a higher speed, because they can climb the crown of the pulley.

The result is that a belt can be run at low speeds for longer intervals of time after shafts have gotten out of alignment, thereby lowering the maintenance cost. At the slower speeds, belts out of balance seldom cause trouble, but at higher speeds, particularly when they are running over small pulleys, they are likely to prove quite bothersome.

When belts are operated at very high speeds over small pulleys, the centrifugal tension plus the resistance of the belt to bending, greatly reduces the arc of contact between the belt and the pulleys. In the case of belt drives on centrifugal pumps, high-speed blowers and high-speed wood planers it will be noticed that the belt contact with the small pulleys instead of being 180 deg., as it supposedly should be, may be reduced by centrifugal force to as little as 110 deg., as is shown in an accompanying sketch.

This decrease in arc of contact can be observed on a belt that is giving trouble from this cause. To make the observation it is best to place a piece of white cardboard behind the edge of the belt and the rim of the pulley, and then sight along the pulley face, noting, while the belt is in operation, how far

*Note—The first article of this series entitled, "Factors in Determining Proper Distances for Leather Belt Drives," appeared in the May issue, the second, "Fixed and Flexible Idlers on Leather Belt Drives," in the July issue, and the third, "Influence of Pulley Diameter on Power Transmitted by Leather Belt Drives," in the August issue.



Position of fixed idler with small high-speed driven pulley.

For high-speed operation of belts when the driven pulley is the smaller a fixed idler should be placed as shown to secure the greatest wrap on the small, driven pulley. This position also serves to check the belt at the point where it runs on to the pulley, thereby securing greater pressure between belt and pulley. When the small pulley is the driving pulley a flexible idler must be used.

back the light can be observed, between the pulley face and the belt.

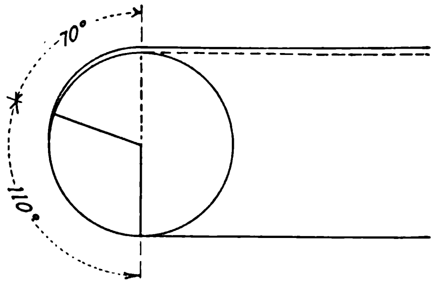
In the case of pulleys with a crowned face, the point at which the belt actually leaves the pulley is back of the place observed, but is hidden by the crown.

Wider belts, that is, 18 in. in width and over, which are generally given more careful attention, and are used on drives that are set securely on rugged foundations, seldom give trouble when operated under normal conditions at a belt speed of less than 6,000 f.p.m. Although many belts are operated in excess of this speed, it will be found that they generally require frequent attention and often are very short lived.

Some belts have been operated up to 8,000 f.p.m. In fact, it is not uncommon for the edger belts in lumber mills to operate at speeds of 7,000 to 7,500 f.p.m. In the case of several high-speed drives observed, the belt proved very troublesome, but when the speed was reduced the belt lasted much longer and gave better service. This improvement was brought about in one case by changing the 96-in. driver operating at 300 r.p.m. with a rim speed of 7,500 f.p.m. to an 82-in. pulley with a rim speed of 6,400 f.p.m. The edger pulley was reduced from 19 in. to 16 in. in diameter, which still drove the edger at 1,500 r.p.m.

The centrifugal tension in the 14-in. double (28-oz.) belt was reduced by approximately 322 lb. The 16-in. diameter pulley had about the same surface contact as the 19-in. pulley, because the slower speed allowed the belt to make a greater arc of contact on the edger pulley. The capacity of the belt was slightly higher at 6,400 f.p.m. than at 7,500 f.p.m., therefore, the belt not only operated better, but required less attention.

Belts, like almost all other mechanical equipment, have critical speeds. Very little is known about the critical speeds of belts, because it has heretofore not been a serious or general problem. It is, however, known that the critical speed is different for nearly each belt thickness of the same tannage. The critical speed of a belt is usually indicated by the belt riding from side to side on the face of the pulley or by violent flapping of the slack strand. Changing the center distance, load, or belt speed, shifts the critical point for that particular belt or drive.



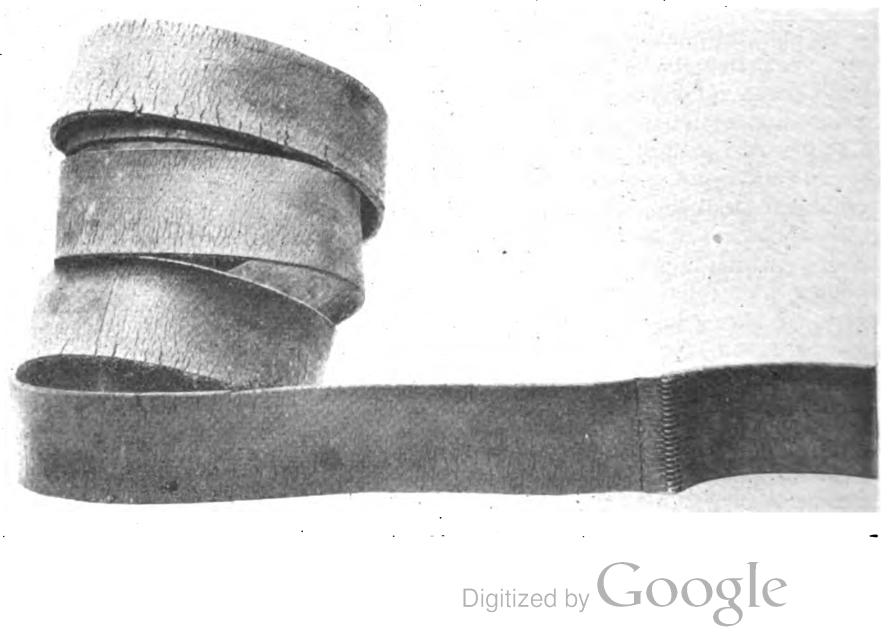
Effect of high-speed operation on arc of contact.

This sketch shows the amount of lost contact on a high-speed belt due to the centrifugal force and the resistance to bending at the high speed. This loss of contact on a belt operating around 7,000 f.p.m. under normal tension will often amount to 70 deg. as shown here, on a drive where ordinarily an arc of contact of 180 deg. would be expected. Increasing the tension to maintain contact will cause operating troubles, high maintenance cost, and short belt life. Frequently, it is possible to transmit as much power by decreasing the belt speed enough to overcome this centrifugal loss so that the full arc of contact is maintained, and at the same time increase the belt life and decrease the operating trouble and maintenance expense.

When a new belt is purchased to replace an old one, it will, if it is of a different thickness, seldom have the same period for that particular drive. Troubles of this nature have been encountered on automatic refrigerating machine drives. Under no-load or partial load the belt ran satisfactorily, but when the heaviest work was being done the belt would ride from side to side, sometimes so violently that it looked as though it would come off the pulleys.

A study of the drive showed that the motor was loaded less than 70 per cent of the time; therefore, by replacing the motor pulley with one of smaller diameter the belt speed was reduced and at the same time the peak load on the motor was also reduced, thereby incidentally cutting down the power company's demand charge. At the slower speed the belt ran satisfactorily and the motor operated approximately 80 per cent of the time.

A little care given to new, high-speed belts will add much to their life and service. When a new belt is installed on a drive where the belt speed is high, it is advisable before running to dress the belt thoroughly with a good belt dressing, preferably one of a liquid type which strikes readily into the leather. A high-speed belt should be run under no-load for some time, until the internal fibers are properly lubricated and the belt limbered up. When a load is put onto a new belt which has not been treated either by the manufacturer or after installation, the belt will be found to heat from the



Effect of high-speed operation on belts that are improperly dressed.

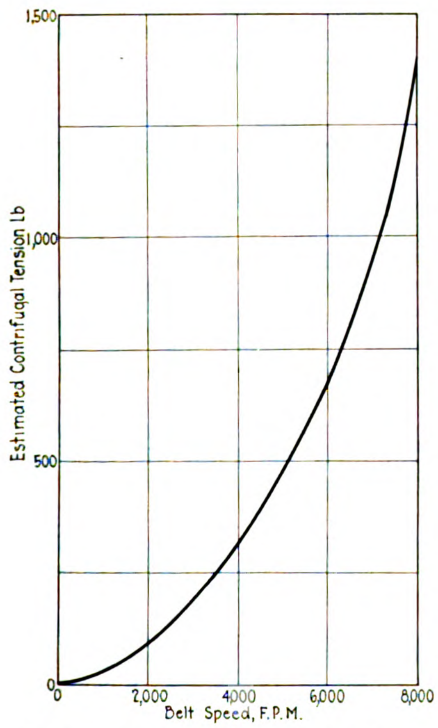
High-speed belts, such as are used on blowers and some woodworking equipment, should be well dressed when installed and permitted to run-in under light loads to limber them up. Otherwise the belts are likely to heat up because of the excess friction of the stiff belt as it slips instead of bending and hugging the pulley.

internal friction caused by the rapid bending and straightening. In some cases the heating is so great as to cause early cracking of the surface, as is shown in an accompanying illustration, and results in premature wearing out of the belt.

Drives that give trouble as a result of poor arc of contact caused by excessive belt speed and have a small driven pulley can be greatly improved by placing a fixed idler on the slack strand, as close as possible to the driven pulley. Locating the idler in this position not only increases the arc of contact on the small pulley, but through checking the motion caused by the bending of the belt around the idler, keeps the belt wrapped more tightly around the small pulley and, at the same time, permits running the belt under a lighter tension.

When the small pulley is the driving pulley a flexible idler must be used. When flexible idlers are used on high-speed drives it is advisable that they be equipped with a pulley that has been balanced dynamically at the belt speed and that the frame of the idler be equipped with checks to control the rebound.

The above suggestions are not cures for high-speed belt troubles, but will be an aid toward increasing belt life and lessening the maintenance costs. Whenever possible, it is better to avoid high speeds, thereby eliminating the cause of the troubles.



This shows the estimated centrifugal tension on a 14-in. heavy double belt at different speeds.

Socketing Wire Cable

NOT long ago an elevator in a comparatively new office building fell from the sixth floor to the basement with the result that a number of persons were injured. The investigating committee reported that the break had occurred immediately adjacent to one of the sockets, but that the tensile strength of the broken rope was amply sufficient to hold double the load of the elevator when it fell.

A mine operator had similar trouble with hoist rope some years ago. Just previous to the time the trouble developed it had been necessary to hoist an 8-ton engine to the surface. Because the age of the hoisting rope was not known a thorough inspection was given it before the task was assumed. Not a broken wire was in sight and little outside wear was visible. The engine was hoisted successfully, but three days later the rope broke with the ordinary 3-ton load. The break occurred in one of the sockets.

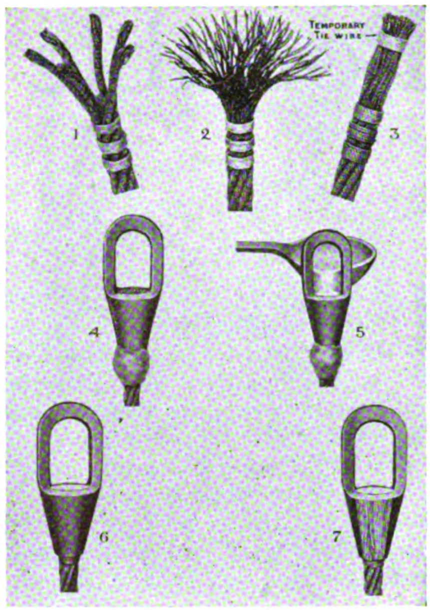
It is recommended that resocketing be done every six months, except in extreme cases when it may be needed every three months. This is necessary because, generally speaking, hoisting, shovel and dredging ropes are not accorded the maintenance to which they are entitled. Operators are inclined to inspect superficially, records are seldom kept, and resocketing is neglected. Complete replacement of a rope at stated intervals, regardless of visible condition is good practice.

In resocketing a wire rope, measure back from the end of the rope a distance equal to the length of the tapered basket of the socket. Tie securely at this point with soft, annealed iron wire and add two additional tie wires below the first.

Open up the strands and cut out the hemp core as far down toward the tie wire as possible as shown at *1* of the accompanying diagram.

Unlay each wire and straighten so as to form a "brush" as shown at *2*. On large ropes, it would be necessary to use a small pipe over each wire to straighten so as to remove most of curl from the wire. If the wire is very greasy, hold the "brush" over a pail of gasoline with the wires down and wipe off the grease with waste or a paint brush dipped in the gasoline. Wipe dry.

Dip the "brush," holding the wires point down, into a pot of muriatic acid solution composed of 50 per cent water and 50 per cent commercial acid. Insert to a depth that will *not* immerse the end of the hemp core. Keep in the acid until the wires are clean. Still holding the wires down, withdraw from the acid and knock the rope sharply with a stick (broomstick or hammer handle).



Steps in fastening a socket to the end of a wire rope.

The cable end is prepared as shown at *1*, *2*, and *3* and then inserted in the socket as shown at *4*. Melted zinc is poured over the end as shown at *5*, resulting in the finished socket shown at *6*. This illustration furnished through the courtesy of the American Cable Company.

Place a temporary tie wire, as shown at *3*, over the ends of the "brush" taking care not to handle the cleaned wires with greasy hands or tools. Then insert the rope end into the socket and cut the temporary tie wire.

Set the rope vertically in a vise with the socket placed so that the wires come flush with the top of the basket of the socket with the wires spread out. Seal the bottom of the socket with clay or asbestos as shown at *4*.

If cold, warm the socket moderately and then pour pure molten zinc (not babbitt, lead or other alloy) as in *5*. Tap the side of the socket with a light hammer while the zinc is still fluid, so as to jar the zinc into the crevices between the wires. When cool, remove the fire clay and the serving wires, and the joint shown at *6* will be the result. It will help slightly in the flowing of the zinc among the wires to put a small quantity of salammoniac crystals over the wires prior to pouring the zinc. A phantom view of the zinc cone with imbedded wires is shown at *7*.

Portable Equipment

Saves Repairmen's Time

By DONALD A. HAMPSON

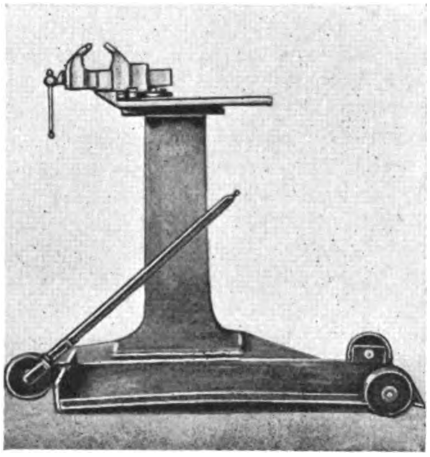
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

LACK of proper tools and facilities for doing a repair job is responsible for a large amount of the wasted time and high cost of building and equipment maintenance. One contributing factor to this waste is the fact that many repair jobs cannot be taken to the shop but must be performed out in the plant, often where tools and conveniences such as a bench and vise are not available.

The accompanying illustration shows two devices that have saved steps and hours by the hundred for the repair men in one industrial plant. One of these units is a bench vise and flat, cast-iron table top mounted on a cast-iron pedestal. The other device is an extra-low truck for transporting this vise and any other material, supplies, or equipment that may have to be moved. Except for one 4-in. Parker vise, the equipment was all made in the plant.

This factory occupies 24,000 sq.ft. of floor space on three floors, with the manufacturing machine shop and the repair department on the lower floor and other departments occupying the floors above. In the departments devoted to woodworking, pressed metal, and automatic finishing processes, no vises are provided as they are not needed for production. This causes some inconvenience on repair jobs. For example, if a machine has broken down, needs some adjustment, if some overhead work is being put up, or if a piece of electrical machinery requires a little attention, a vise is then frequently needed every few minutes and the time a man spends walking to the nearest one not only increases the cost of doing the work but also delays it. It is in such cases as this that the portable vise stand soon pays for itself. Even in other departments the repairman can carry on his work without disturbing a bench hand.

The vise stand was made up from a pedestal that the factory puts under one of its products. The table top, which is about 24 in. square was made from another standard part and was planed off on both sides. When making devices for plant use it is often possible to employ pieces which are defective or damaged and otherwise would go for scrap. The pedestal and table were bolted together and the vise was then bolted on top. The complete unit weighs nearly 200 lb., which makes it solid enough for any work required when it rests, unbolted, on the floor, but is not too heavy to drag a short distance to a more convenient working point, or to handle on and off trucks, particularly the low truck illustrated. This plant also uses several of these portable vise stands for special production work where a vise is needed only occasionally, or at some distance from the benches.



These two convenient and time-saving pieces of equipment for maintenance work have repaid their cost several times over.

The low truck is used by the maintenance department to carry repair and replacement material and supplies to the job. The bench vise mounted on the cast-iron table top and pedestal is also taken to the job on this truck. The vise saves time in that it can be placed where most convenient instead of making it necessary for the repairman to walk back and forth to a bench vise and perhaps interfere with a bench hand. Also, some departments, such as woodworking, have but few, if any, vises.

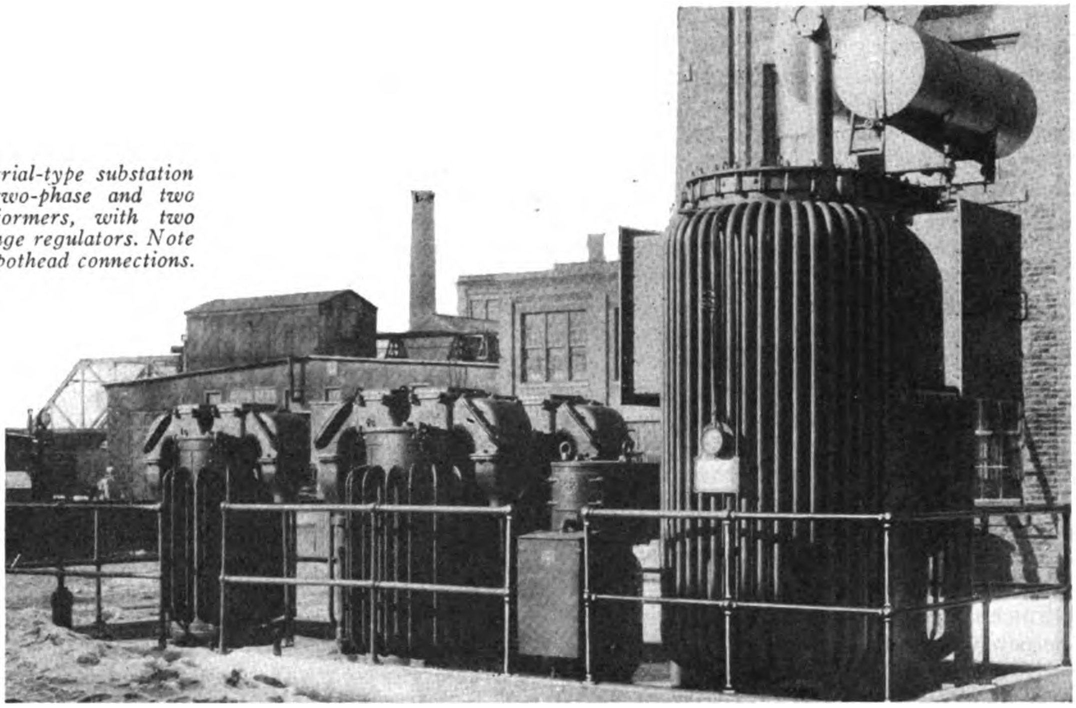
The low-platform hand truck shown in front of the vise was made especially for transporting heavy pieces of equipment about the shop. The building has good floors and so this truck could be made with only $\frac{3}{4}$-in. clearance, which made it possible to keep the total height of the platform within 2 in. of the floor. This is much lower than any of the standard factory trucks which have platforms from 12 to 30 in. above the floor.

In every industrial plant there is a certain amount of moving to be done on "floor" parts; that is, parts which are too heavy or bulky to put in stock bins and so always rest on the floor. These may be manufactured goods, portable machines or new equipment or supplies used for replacement or new installations in the drive or power transmission system in the line of production.

The repairmen's vise pedestal is a good example of this. It is too heavy for a man to pick up and carry around, no portable hoist or trolley system in this plant would take it to many of the places where it is wanted, and it would be inconvenient to put it on a standard shop truck with even the lowest platform. However, one man can tilt it and work it over upon this low platform truck.

The platform of this low truck was made from an 18-in. x 36-in. sheet of $\frac{3}{16}$-in. steel. This has been stiffened with 1-in. angles along the sides and wider pieces where the three, 4-in. x $1\frac{1}{2}$-in. wheels are. The pivoted front wheel has the handle attached to it and the men do not find it hard to move any loads that are ordinarily handled.

It does not take the experienced maintenance man long to appreciate the value of these two simple pieces of equipment. The accompanying illustration was taken when the vise was brought on the truck to the woodworking department to fit a bearing on a saw. Because these devices are so easily brought to the job and in addition are so necessary to save time and also do good work, they have saved their cost many times over. The vise is mounted at a good height for working and it is solid—two important considerations so often found lacking in many portable appliances.



This is a 2,300-volt industrial-type substation containing a 1,500-kva., two-phase and two small single-phase transformers, with two single-phase induction voltage regulators. Note the inclosed terminals and pothead connections.

Characteristics Govern Transformer Choice

By DAVID R. DALZELL
Transformer Division, Central Station Dept., General Electric Co., Pittsfield, Mass.

THERE is a constantly growing tendency for industrial plants to purchase electrical energy from central stations. Inasmuch as the energy is usually supplied at high voltage, transformers are required to step down or lower the supply voltage for distribution throughout the plant.

When selecting the transformers for an industrial installation it will be advisable for the operator to obtain the benefit of the central stations' experience with this class of apparatus, in case he is not thoroughly familiar with it. In general, however, certain characteristics must be definitely established in order for the manufacturer to fill the order at minimum expense to the purchaser and in the minimum time. These characteristics are:

(1) Frequency, kva. output and voltage rating.
(2) Number of phases.
(3) Method of cooling.
(4) Electrical connections.
(5) Type of external connections.
(6) Arrangements for handling.
(7) Requirements for special applications.

The meaning and importance of these characteristics will be discussed in the following paragraphs:

Frequency——The frequency rating is always that of the supply circuit expressed in cycles per second or simply as "cycles." The commercial frequencies most commonly used are 25, 50 and 60 cycles. If frequencies other than that of the supply circuit are desired, special generating or converting apparatus will be required.

Kilovolt-ampere Output——Motors are rated in horsepower and thus have a definite relation to the kilowatts required, as 1 hp. equals approximately three-quarters of a kilowatt. Transformers, however, are rated in kilovolt-amperes, the relation of which to kilowatts is dependent upon the power factor of the load. A load composed primarily of lighting has a very high power factor, from 95 to 100 per cent, so that the kilovolt-amperes and kilowatts are practically identical. A large number of lightly-loaded induction motors on a system might cause the power factor to drop as low as 50 per cent, which would require that the transformer rating in kilovolt-amperes be double the kilowatt load, unless the power factor were improved by a synchronous condenser, synchronous motors, or by capacitors.

Modern transformers are designed in accordance with A.I.E.E. standards, and are rated in accordance with the maximum kilovolt-ampere output which they will deliver continuously without exceeding a temperature rise of 55 deg. C. (99 deg. F.) above the cooling medium. A careful study should be made of the load that the transformer is expected to supply throughout the day in order that the rating may not be exceeded by the maximum demand for any appreciable period. Future plant extension should also be considered, because it may be more economical to install, initially, transformers that will be capable of handling the ultimate load.

Voltage Rating——The high-voltage rating of the transformer will be governed by the supply voltage and may range from 460 to 33,000 volts

or in some cases, even higher. The low-voltage rating will be that required by the load. Common practice is to use 115/230-volt, single-phase, three-wire distribution for lighting, and 230, 460, 575 or 2,300 volts for the power load. It is generally desirable to supply the lighting and motor loads from separate transformer banks because of lamp flicker due to the voltage variations caused by the fluctuating motor load, and also to assure continuity of lighting service in the event of motor trouble. In large manufacturing plants it may be found economical to step down the supply voltage to some intermediate voltage such as 6,600 or 2,300 volts for further distribution to load centers throughout the plant, each of which may be provided with transformers to reduce the voltage to the proper value.

If the transformers are located near the end of a long transmission line in which there is a considerable drop in voltage, taps will be required in the high-voltage windings of the transformers so that the tap connection corresponding to the actual supply voltage may be chosen and the load voltage thus kept at the proper value. Certain voltage and kilovolt-ampere rating for distribution and step-down power transformers are being considered for adoption as standards by the National Electric Light Association, representing electrical operators, and the National Electrical Manufacturers' Association, representing the manufacturers of electrical equipment. These proposed standards for voltage ratings are given in the accompanying table. Transformers of the more commonly used ratings are kept in stock by the manufacturer and, therefore, may be obtained in a fraction of the time that would be required if special ratings were ordered.

Number of Phases—— Usually three-phase power is supplied by the central station. In such cases a three-phase transformer may be used, or three single-phase transformers may be connected to form a three-phase bank. The latter alternative is by far the more flexible, for the following reasons:

(1) Single-phase units are smaller and, therefore, easier to handle.

(2) One single-phase transformer may be kept as a spare unit for more than one three-phase bank.

(3) If a bank is delta-delta connected, one transformer may be removed and the other two units operated at reduced output, as will be shown later.

If, however, a number of separate transformer banks are involved, and especially if floor space is at a premium, three-phase units may well be used.

Transformers for two-phase operation or for effecting three-phase to two-phase transformation may be obtained in a single unit or in two separate units. In this case, also, the advantage of interchangeability will usually warrant two separate units.

Six- or twelve-phase voltages are often used to supply synchronous converters, and as floor-space is usually a determining factor in the selection of transformers for this class of service, a single unit is ordinarily used to transform from a three-phase supply.

Method of Cooling——The majority of transformers are immersed in oil, which not only increases considerably the value of the insulation on the windings, but also provides an effective cooling medium. The heat from the core and windings is carried to the tank by the oil, and dissipated from the tank surface into the air. There is practically no limit to the size of a self-cooled transformer that may be built. For indoor installation, however, particularly in the case of large units, an adequate supply of cool air of not more than 40 deg. C. (104 deg. F.) temperature is necessary.

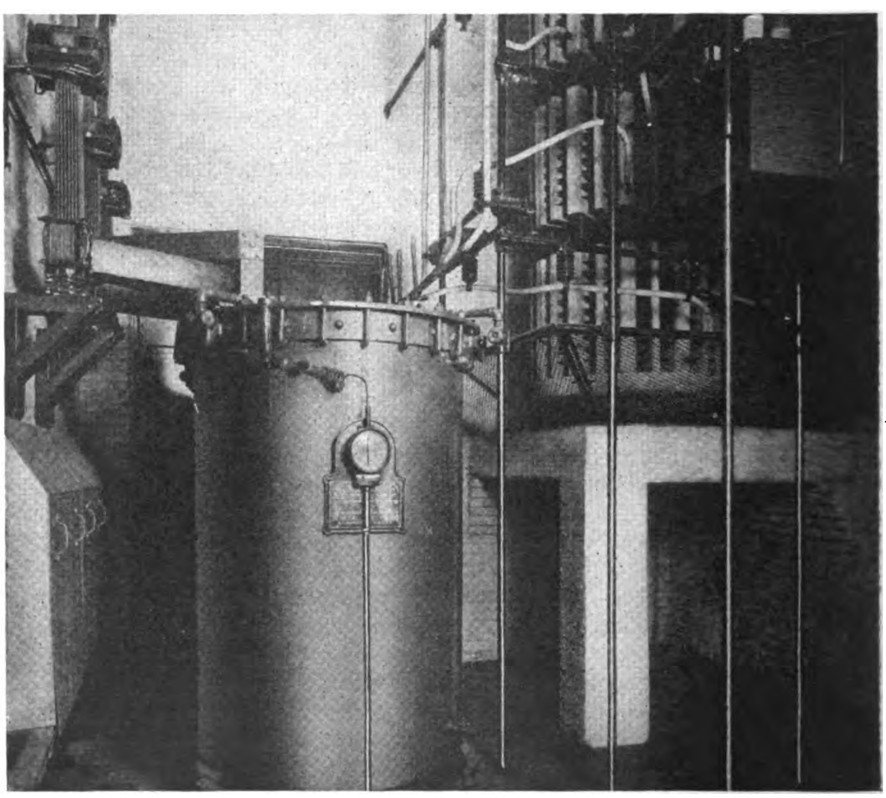
In case it is necessary to install a transformer in a vault where a supply of air is not available, a water-cooled unit may be required. In this type the transformer is cooled by water which circulates through a copper coil placed in the oil at the top of the tank; therefore, a supply of water is necessary.

Transformers of not more than 50-kva. rating, designed for circuits of 600 volts or less, may be obtained in the air-cooled type. No oil is required as the natural air circulation will properly cool the transformer. Such units are very compact and in the smaller sizes may be mounted on a wall and provided with fittings for conduit wiring installation.

Most modern transformers are suitable for both indoor and outdoor installation. The location should be specified, however, as in the case of transformers that are installed outdoors, and for special applications requiring very heavy current, special provision may be necessary for bringing out the leads.

Electrical Connections —— There are various methods of connecting the three units of a three-phase bank. High-voltage or low-voltage windings, or both, may be connected in delta or in Y and in each case in several different ways. The accompanying

A three-phase, water-cooled, 1,550-kva., 60-cycle, 12,000/175-volt transformer with current-limiting reactors supplying a 3-ton electric steel furnace.



voltage-vector diagrams show the three different groups having different phase displacements between high- and low-voltage windings, which are marked *H* and *X* respectively. The phase displacement must be considered in the case of extensive relaying of the distribution system, but assumes major importance in the case of three-phase transformers that are to be operated in parallel with units already installed.

Parallel Operation——Transformer banks having one group of connections cannot be operated in parallel with those of another group. For example, a bank connected delta-delta, Figs. 1 and 3 in the diagram, will not operate in parallel with one connected Y-delta, as in Figs. 6 and 8. Three-phase transformers for parallel operation must be designed with the same phase displacement as that of the existing units. Single-phase transformers are more flexible, and if they have been designed for connecting in Y, any group may be obtained by the proper external connections between transformers, regardless of their polarity.

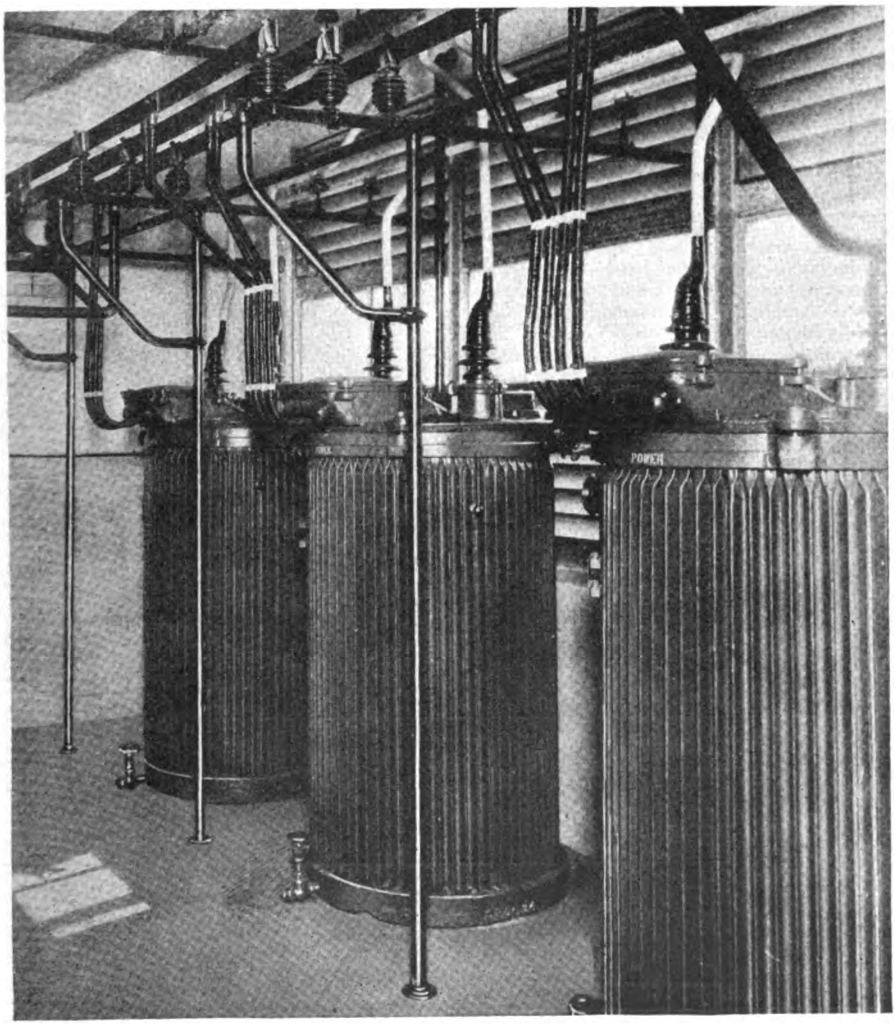
In order for a transformer to operate properly in parallel with another of the same kilovolt-ampere rating, it is also necessary that the per cent impedance voltage of each unit be approximately the same. If the impedances are different the transformer having the lower impedance will be overloaded. This also holds true in the case of three single-phase units operating in a delta-delta-connected three-phase bank, for if the impedance of one unit differs from that of the others, a balanced three-phase load will not be equally divided between them.

However, a difference in impedances may be equalized by a reactor of the proper design placed in series with a transformer having lower impedance than that of the other units in a bank.

It is also necessary that the ratio of low-voltage to high-voltage ratings be approximately the same for each transformer; otherwise current will circulate between units, thereby reducing their useful output.

On modern transformers their per cent impedance voltage as well as the voltage rating are specified on the nameplates; in the case of three-phase units, the phase displacement is indicated diagrammatically. Where new transformers are to be operated with units already installed, the complete nameplate data of the latter, including the serial number, should be given to the transformer manufacturer when placing the order.

Ample ventilation is provided for this bank of 200-kva., 60-cycle, 13,800/230/460-volt transformers, by the louver-windows behind them.



Special Connections——When both high- and low-voltage windings in a three-phase bank are delta-connected, one of the transformers may be omitted and two units operated with the open-delta connection. This connection may prove of value where it is desired to provide transformers for an immediate load and add the third unit at some later period when the load increases. Two units operated in open delta, however, have a combined output of only 86.6 per cent of their total nameplate rating. For example, two 100-kva. single-phase transformers connected in open delta will give a bank output of only 173 kva. The addition of the third unit would increase the bank output to 300 kva. This method of operation is, therefore, not so efficient as when the full delta-delta connection is used.

The open-delta connection will also be found useful for the emergency operation of a delta-delta-connected bank. One unit may be removed and the other two units operated at reduced capacity.

Where it is desired to transform from three phase to two phase or *vice versa,* the so-called Scott or T connection is most commonly used. This requires two transformers, a main unit having 100 per cent line voltage rating and a "teaser" unit designed for 86.6 per cent of the three-phase line voltage. The two units may be made interchangeable by providing an 86.6-per cent and a 50-per cent tap in the three-phase winding of each unit.

External Connections —— Leads are brought out from the transformer in the form of flexible cables or rigid bushings, mounted on or near the top of the transformer, that are suitable for direct connection to the buses. If desired these bushings may be completely inclosed by a steel housing with provision for conduit fitting, thereby eliminating any exposed live conductors. Similarly, potheads may be provided on the transformer, permitting direct connection to underground cables.

Both of these methods of connection find extensive application in industrial installations where it is

necessary to take maximum safety precautions, or to meet Underwriters' requirements.

Arrangements for Handling——All transformers are provided with lifting lugs for handling by cranes. Where the size warrants they are also provided with bosses for lifting by means of jacks.

If desired, large transformers may be equipped with trucks permitting the transformer to be moved in the simplest manner. The truck wheels may be either flanged or unflanged, and arranged for motion either parallel or perpendicular to a vertical plane passing through the high-voltage bushings. The track gage is best governed by the size of the transformer tank, but if desired standard or any other track gage may be supplied.

Requirements for Special Applications——The satisfactory operation of transformers can best be assured by specifying the characteristics mentioned above. For special applications, a few of which are mentioned below, detailed information regarding the nature of the service and character of the load should also be included.

Use of Auto Transformers——Auto-transformers may be economically used instead of straight transformers, if there is no objection to an electrical connection between the two circuits, and where the low voltage is 50 per cent or more of the high voltage. As the energy actually transformed is less than that in a two-winding transformer having the same output, the cost, size and weight are considerably less. Where Underwriters' requirements permit, they may be used when both circuits have relatively low voltage, such as for supplying 115-volt lighting service from a 230-volt motor supply or *vice versa,* and as balancing coils on 115/230-volt, three-wire circuits. Auto-transformers should not be used, however, without careful consideration of their effect on the entire distribution system.

Furnace Transformers——The characteristics of induction or arc furnaces are such that the transformers supplying them must have a relatively high reactance. In the case of resistance furnaces, normal reactance designs are usually satisfactory. In all cases, however, the windings must possess extremely high mechanical strength to enable them to withstand the forces caused by sudden current changes during operation of the furnace. A number of regulating taps are usually necessary for supplying a wide range of voltages to the furnace.

Transformers for Motor Loads——As in the case of furnaces, motors that drive hoists, rolling mills or similar apparatus, are subjected to rapidly fluctuating loads, which require that the transformers supplying them possess adequate mechanical strength.

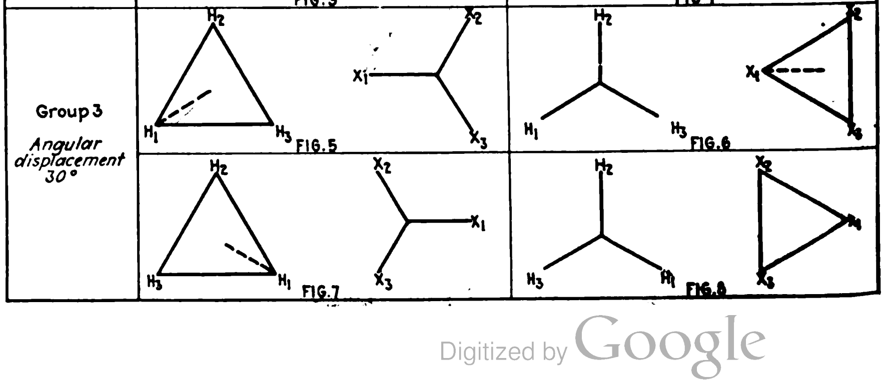
All equipment that is subjected to vibration such as encountered on electric shovels, trucks, and the like, must be designed as compactly and as sturdily as possible with ample bracing to withstand the mechanical shocks to which it will be subjected. Specially-designed transformers are available for such service.

Transformers supplying synchronous converters usually must be designed for phase transformation and a certain reactance, depending upon the type of converter. Three-phase to six-phase transformation is most commonly encountered in practice. As reduced voltages are required for starting the converter, special starting taps are usually provided in the low-voltage winding. In accordance with A.I.E.E. standards, transformers for railway converters should have a nominal rating which may be exceeded by 50 per cent for 2 hr. without causing the temperature rise of the windings above the cooling medium to exceed 60 deg. C. (108 deg. F.).

Although most transformers are provided with taps for maintaining the low voltage approximately constant when the supply voltage drops below normal, the tap connections cannot be changed until the transformer is disconnected from the supply line, thereby interrupting service. In cases where it is essential or desirable that service be maintained—as in the case of electric furnaces—large transformers can be obtained which are arranged for changing the voltage connections without dropping the load. These equipments may be hand-operated or motor-operated with remote or even automatic control.

Proper installation of transformers will be discussed in a succeeding article, to appear in an early issue.

Lead markings and voltage vector diagrams for the usual three-phase transformer connections, adopted by the American Engineering Standards Committee.
In these diagrams *H* and *X* denote the high- and low-voltage sides respectively.



Methods of Increasing Grip of Open-End Wrenches

A WRENCH that has become oversized from use may not only be useless, but dangerous to anyone who uses it. In such a condition, the strain on the jaws when tightening a nut, plug or other screwed part will tend to spring the jaws farther apart.

Two methods of increasing the grip have been found to be very satisfactory. The first scheme involves the use of thin pieces of sheet iron bent to the shape of the jaw, which enables the wrench to grip the nut firmly.

If the part cannot be turned, the outside of the wrench jaws can be ground flat in order to permit a larger wrench to be placed over the first wrench, as the second scheme to use. Turning these wrenches jointly will make it possible to loosen the part with little effort. G. A. Luers.
Washington, D. C.

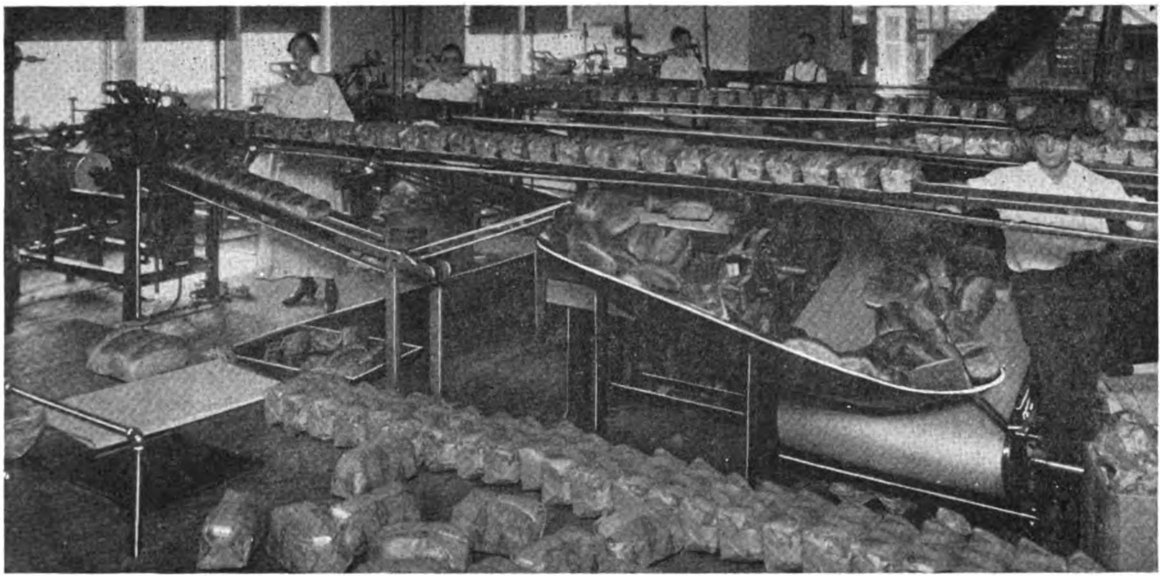


Fig. 1—Continuous method of delivering loaves of bread from the coolers to the wrapping machines. This is an excellent example of the mechanical handling of commodities, and of the principle of continuity.

Floor to Floor Conveyors

By EDWARD J. TOURNIER
Mechanical Engineer,
Robbins Conveying Belt Co.,
New York, N. Y.

THE impression in the minds of certain executives, that "speeding up" the works results in greater efficiency is due, perhaps, to a faintly perceived glimmer of the truth. It so happens that wherever mechanical handling has been substituted for muscle handling, there has been an increase in speed, followed either by greater production or by a reduction in labor cost. At the same time something else has taken place which is accepted as a matter of course, without a great amount of thought. In most cases involving a system of conveyors, the principle responsible for the improvement, is not actually the speed of the conveyors, or other apparatus; it is continuity in operations or processes, in every case, that makes possible the remarkable results obtained in all mechanicalized industries. This principle is illustrated in Fig. 1.

Transferring miscellaneous commodities from one part of a manufacturing building to another involves a number of problems, each of which may be solved by the application of suitable equipment. Also each handling operation in the plant can be carried out by some specific type of machine.

In giving consideration to this subject, it should be pointed out that the problems of industrial conveying may be broadly classified as interplant transport, interdepartment transfer and factory conveying. Each of these divisions is linked with some general type of equipment of more or less diversified design. The first is especially dependent upon company policy, while the two latter are specifically the problem of the factory executive. It is the purpose of the present discussion to show applications of different classes of conveying equipment, to factory production.

Most food products, exclusive of fresh meat and vegetables, are delivered to the consumer in some form of container or are handled during preparation, in containers. Boxes, barrels, bags, cans and the like are their most common forms. Cotton, straw, excelsior, oil cloth, are handled in the form of bales or rolls. Articles of furniture also, from beds to pianos, have been brought into the mechanical assembly line.

Various kinds of breakfast cereals which are packed in cartons are handled by a type of conveying equipment which is almost in universal use for the purpose. The small packages of shredded wheat after being filled, are placed in large cartons which are unsealed. From the packing room, the cartons pass down a roller chute and over a gravity roller conveyor to a sealing table. From this point another gravity roller conveyor carries the sealed cartons to the foot of an inclined push-bar type elevator which discharges to a storage conveyor line.

The gravity roller conveyors used in the Shredded Wheat factory at Niagara Falls, N. Y., are of two general types. The first is made up of steel tubes having ball bearing journals in each end. A through axle made of cold rolled steel carries each roller and both ends of the axles are supported on longitudinal members of the conveyor.

These members may be either a flat steel bar or an angle iron, depending on the load to be carried. The

second type consists of two parallel flat-steel or angle-iron members, each of which carries a series of rollers mounted on stud shafts or pins. The rollers are made of pressed steel and are provided with ball bearing hubs. The latter design of conveyor is generally known as a "wheel conveyor," and it is identified as such.

Handling Commodities Between Floors

The push-bar type of inclined elevator, such as the one at the shredded wheat factory consists of two strands of malleable-iron roller chain, connected at suitable intervals by pusher bars. The latter consist of cold-rolled steel rods each of which passes through a pipe sleeve that is free to revolve around the rod. The pusher bars are generally spaced 3 ft. 6 in. apart.

Usually the elevator is mounted on a structural steel frame whose essential elements are four angle-iron tracks for carrying the roller chains, and which includes supports for the transmission machinery as well as for the takeups.

However, between the upper and lower strands of chain there is a sheet steel apron extending the full width of the elevator. This apron serves as a table or slide for the commodity to be handled. When a package is placed on the loading plate at the foot of the elevator, it rests upon the apron until it receives motion from one of the push bars, and is finally delivered to the discharge point, which, in some cases, may be 40 ft. or more above the loading point in the building.

Fig. 2—Working position of the unloading fingers of a tray elevator handling miscellaneous articles in a large grocery warehouse.

The machine in the foreground is a short-section, steel-apron conveyor used to assist in rapid unloading of the tray elevator.

Push-bar elevators generally run at a chain speed of from 40 to 60 f.p.m., and are usually driven through spur gears by means of electric motors. It is desirable in this type of equipment, as well as for belt and assembly conveyors, to use inclosed speed-reduction units rather than open spur gears.

It is a requirement established by the nature of the commodities handled, that probably 90 per cent of the belt conveyors used for transporting packages or packed goods must be of the flat-belt type to insure the careful handling required.

There is more than ordinary interest attached to the three forms of package handling by means of roller conveyors, flat belt conveyors and push-bar elevators. This is because wherever quantity production of package food commodities is necessary, these three types of equipment will be found in use almost exclusively. They are practically noiseless in operation, clean and inexpensive to run.

In addition to breakfast cereals, which we have seen handled in quantity, there are a variety of other products and beverages that are being transported by similar machinery and by different combinations of the various types.

Most of the materials entering into the manufacture of clothing, from hats to shoes are most successfully handled mechanically if they are confined in some form of container or wrapper. These are usually of three classes: bales, boxes, and bags, because the contents may be then compressed into a smaller bulk, and consequently a larger quantity can be handled on a given size conveyor, than if the materials were in their natural state.

Cotton is ordinarily compressed

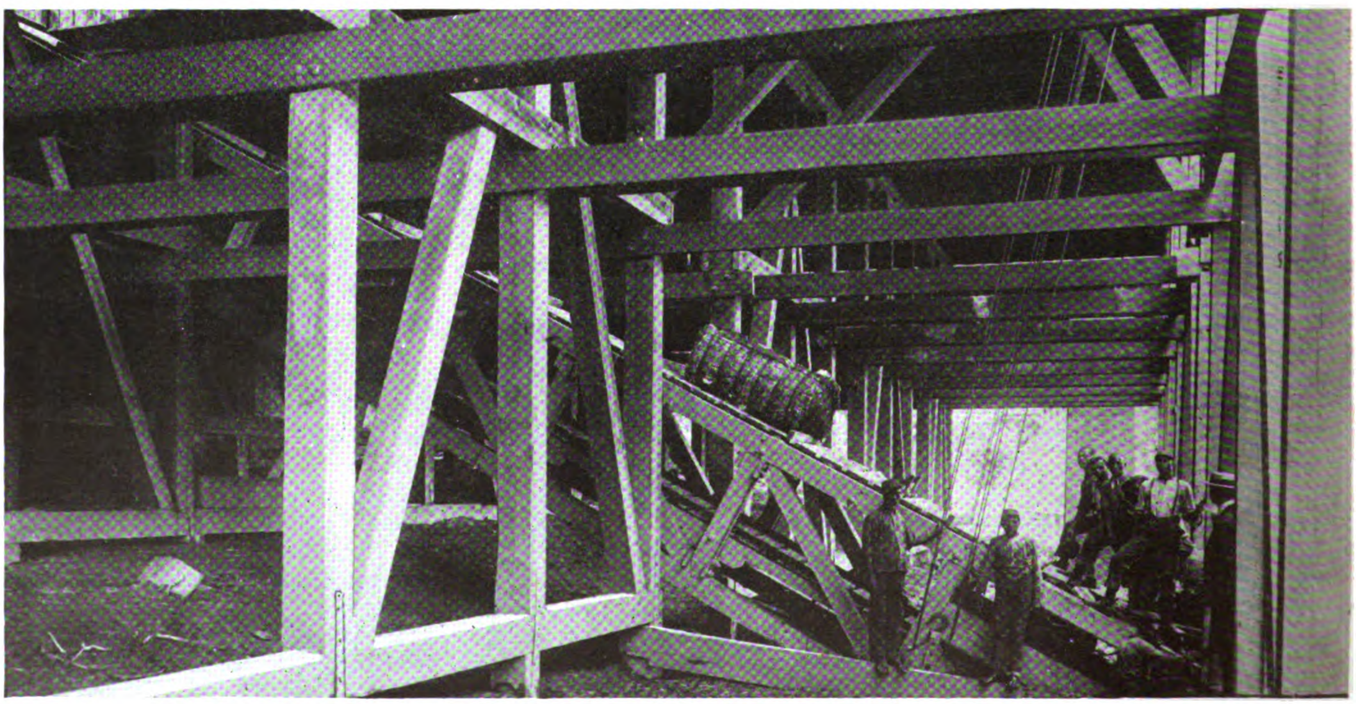


Fig. 3—Loading end of a wood apron conveyor handling bales of cotton from the dock to the warehouse.

The conveyor is hinged, so that it can be raised, thus clearing the floor for other uses.

into bales weighing about 500 lb. Wool and silk are generally made up in skeins packed in boxes. The manufactured forms of these products may be either rolls or bolts of cloth.

Specific Machines for Each Class of Service

Two general forms of conveying and elevating equipment are in use for handling the different classes of articles enumerated, depending upon their weight and bulk. In general, those commodities that are packed in bales and large boxes are carried on wood or steel apron conveyors and tray elevators as in Fig. 2, and all of the lighter packages such as small boxes, bags and cartons are transported on light flat belts and gravity roller conveyors. When it is necessary to elevate small articles this is done with the push-bar type of elevator previously described.

Apron conveyors, whether of wood or steel construction have been standardized as to type of chain and slats.

These conveyors consist of two parallel strands of chain connected by a series of slats each equal in width to the pitch of the chain links. This forms a continuous apron of any desired width. The slats may be either of wood or steel plates having a narrow flange at their edges. This is for adding stiffeners which an unsupported plate does not possess.

Both the upper and lower strands of chain travel on angle iron or industrial-type rails and pass over suitable sprockets at either end, or terminal, of the conveyor. One of these terminals has adjustable bearings or "takeups" to compensate for the stretch in the chain. The other, or drive end is connected through a suitable transmission to an electric motor.

A very extensive application of apron conveyors is in transferring bales from the warehouse to cars or *vice versa*, as illustrated in Fig. 3 on page 518.

Such a conveyor, 36 in. wide and 200 ft. long will handle 300 bales weighing 500 lb. each, per hour at a speed of 50 f.p.m., and requires a $7\frac{1}{2}$-hp. motor for operation under maximum load conditions.

In large textile mills, where heavy rolls of cloth, or bales of cotton must be transferred from one floor to another, the tray elevator is most commonly used. This apparatus, as shown in Fig. 4, consists of two parallel strands of chain, usually of steel construction, with a series of

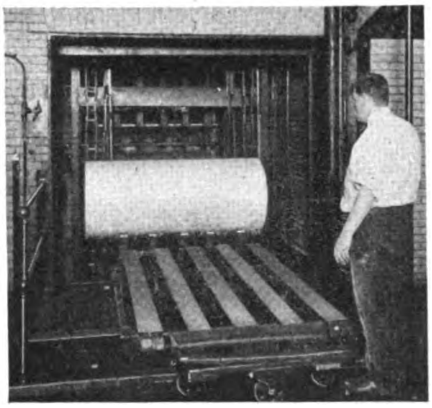


Fig. 4—Heavy-duty tray elevator delivering rolls of cloth at an intermediate floor in an oil cloth factory.
The capacity of this unit is ten, 300-lb. rolls per minute.

swinging trays suspended between the chains. These trays are attached to the chains by means of swivel connections so that they always remain in a vertical position.

The head of the elevator consists of two comparatively short shafts, each carrying one of the drive sprockets and a spur gear, which leaves a clear space between sprockets, for the passage of the trays.

The transmission of power from the head shaft to the electric motor or other source, may be made through a train of spur gears or other suitable means. The introduction of a worm gear reducer between the source of power and the countershaft is desirable in order to provide against the

Fig. 5—Combination of an apron conveyor and a modified push-bar type elevator.
This equipment is used in conveying and elevating boxes of grapes from the receiving room to the press room in a plant of the Welch Grape Juice Co.

reversal of the elevator under load, in case of the failure of power.

An elevator of this type may be designed to receive its load at the bottom, or at any intermediate floor of a building, and to discharge at the top or any point between top and bottom. It may also be made to operate in either direction, if working conditions require it.

Loading and unloading are performed automatically by means of special devices, if desired, or these functions may be carried out in part manually. The loading apparatus, which is commonly known as "loading fingers" consists of a shaft similar to that on the trays, but having the fingers set so that they will allow the tray arms to pass. The shaft which carries the loading fingers may be arranged so that by pulling a lever it is moved out of the path of the trays and the finger bars act as a stop which prevents material being loaded at that point. Another set of loading fingers at some other point is then placed in position for continuation of the work. Unloading is accomplished by means of a similar device, the operation being different from loading, only in that it takes place in the opposite direction.

The Factory System, New Style

The transfer of ancient household crafts to central workshops, and their transformation into factory processes by the introduction of steam power early in the last century, changed human labor from an incidental to a really continuous form. In the factories, manufacturing was still partly hand work, with the speeding up due to the new power and long hours. Here a greater degree of continuity than ever before, was obtained, with workmen servants of the machines in the line of production.

In the modern factory, Fig. 5, the ideal organization is one where the machine serves its attendents and eliminates all unnecessary labor. Although most of the operations consist of lifting or carrying, these are readily performed at great speed, without much manual effort and a good deal better by approved mechanical means.

Factory processes, as a consequence, are being grouped according to a sequence which is best served by a system of conveyors, elevators or other hoisting and transportation facilities. In all cases the aim is the introduction of the principle of continuity, which is replacing manufacturing, in the old style.

Fig. 1—General view of the manufacturing plant showing the arrangement of the heavier machinery on the lower floor, and the lighter machinery on the balconies.

Power Distribution in a Large Machine Shop

By FRANK E. GOODING
Associate Editor, Industrial Engineering
in collaboration with
C. E. BROWN
Maintenance Engineer
Cincinnati Grinders, Inc.,
Oakley, Cincinnati, Ohio

AN ALMOST new building which was conveniently located close to the Cincinnati Milling Machine Company property was purchased and adapted to the production program established for the manufacture of the Cincinnati centerless and center-type cylindrical grinders. The type of building is well shown by the accompanying illustration, Fig. 1.

Briefly the layout of the work of the plant is such that large castings are stored and machined in the center bay which is provided with overhead traveling crane service. Also, the cylindrical grinders are tested, crated and shipped from this center bay. The main floor at each side of the center bay is used for assembling the grinders and for machining parts of medium size which can be handled by five 1-ton and two 3-ton Shepherd cranes, Fig. 2. The first balcony on the two sides contains lathes, milling machines and other machine tools for light manufacturing and tool work; a portion, however, is devoted to engineering and design work. The top balcony is largely devoted to stockrooms.

Material and parts are handled to and from the staggered loading platforms projecting from the balconies by either of two 15-ton traveling cranes with 3-ton auxiliary hoists. This layout keeps the heavier work on the main floor, and all parts progress toward the assembling, testing and shipping departments.

Before going directly into the details of the lighting system, it may be well to take up the general power distribution. Both alternating and direct current are used in the plant. The direct current is used for all variable-speed drives and the alternating current for the constant-speed drives. Three-phase, 60-cycle, alternating current is purchased from the Union Gas & Electric Co. of Cincinnati through the Factory Colony Power Co., at 13,000 volts, and it is stepped down to 110 volts for single-phase lighting and 220 volts for three-phase power use. Direct current is received at 220 volts from the same power company, which supplies direct current to a number of industrial plants in the community.

The substation is placed outside the building at one corner with the leads coming in under the walls to a seven-panel Westinghouse switchboard, Fig. 3. The d.c. power and a.c. power and light are controlled and distributed from this switchboard. The d.c. power is controlled from panel No. 1 on which is mounted two two-pole, 600-amp., fused disconnect switches, a Sangamo watt-hour meter for checking the power consumption, and two 600-amp. carbon-tip circuit breakers. The circuit breakers control the main power circuits on the east and west side of the building.

Panels Nos. 2, 3 and 4 control the three-wire 220/110-volt lighting system. The 600-amp., three-pole, oil circuit breakers for the protection of the main feeders to the east and west side of the building are mounted on panels Nos. 2 and 3. Panel No. 4 contains the main 1,200-amp. fused, dead-front disconnect switch and a recording watt-hour meter.

Panels Nos. 5, 6 and 7 control the a.c. power distribution; the main disconnect switch and recording watt-hour meter are mounted on panel No. 5, and the east and west feeder oil switches are mounted on panels Nos. 6 and 7 respectively.

The general scheme of power and light circuit location is shown in Fig. 4. One set of two 600,000 circ.mil conductors, one set of three 600,000 circ.mil and one set of three 500,000 circ.mil cables take off from the main switchboard for power and light on

the west side of the building. Because of the reduction in floor space on the east side of the building (space devoted to offices and drafting rooms) the power conductors for this side have been reduced to 500,000 circ.mil.

The physical arrangement of conduit as it takes off from the switchboard is more readily explained by the sketch, Fig. 5. All feeders, with the exception of the light circuit for the east side of the building, enter this trough-type, ceiling-mounted junction box, Fig. 5. The parallel a.c. and d.c. power lines then take off from the ends of this box and extend along the east and west sides of the building.

Special junction boxes, Fig. 6, are placed in these parallel power legs at 20-ft. intervals. Sufficient space was provided in these boxes for attaching Dossert cable taps for lines supplying the power distribution panels, Fig. 7. These are Trumbull boxes with slate barriers between the copper buses and each lead is fused with Union refillable fuses. The chief feature of these boxes is that the fuse clips are removable and readily permit the installation of fuses of larger or smaller capacities, depending upon the connected load.

The two feeder lines of three 500,000 circ.mil cables each, Fig. 4, for lighting circuits extend to distribution panels of eight and six circuits each, located on the east and west sides of the second floor, respectively. The six-circuit panel on the west side contains a north and south circuit for each of the three floors. Each of the six sub-circuits supply four of the Trumbull lighting panels. The two extra circuits on the east panel supply the two larger cabinets for the control of lights in the high center bay.

Lighting panels, which are of the Trumbull dead-front type with tumbler switches, as shown in Fig. 7, are mounted on alternate columns within convenient access to the 16 lights which they control. A plug receptacle for an extension light or small electric tool is provided just below each cabinet. In addition, Crouse-Hinds BRJ single-phase receptacle housings for BP plugs are provided at convenient locations for portable tools.

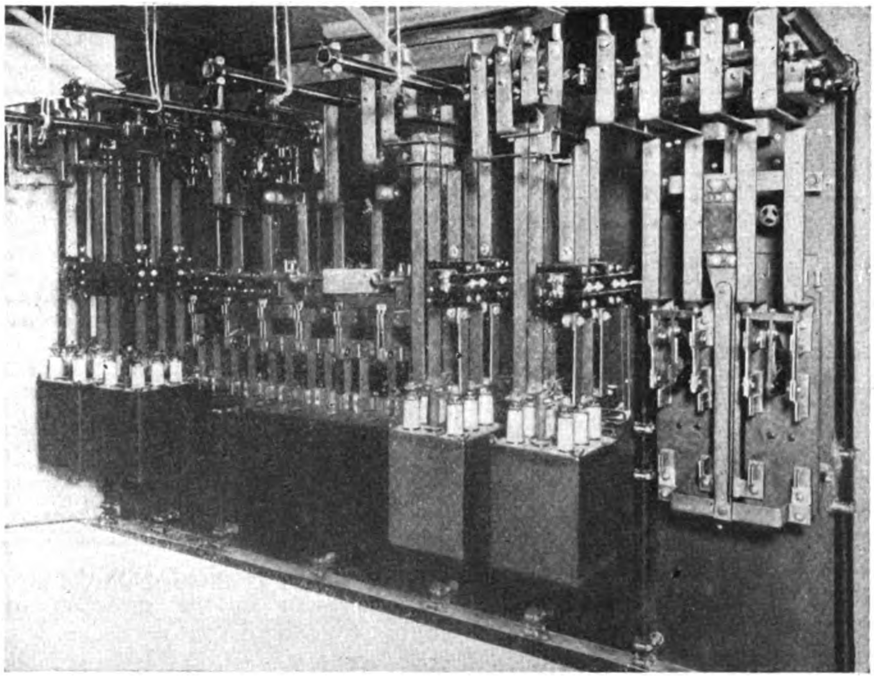


Fig. 3—Rear view of assembled seven-panel switchboard before it was connected for service.

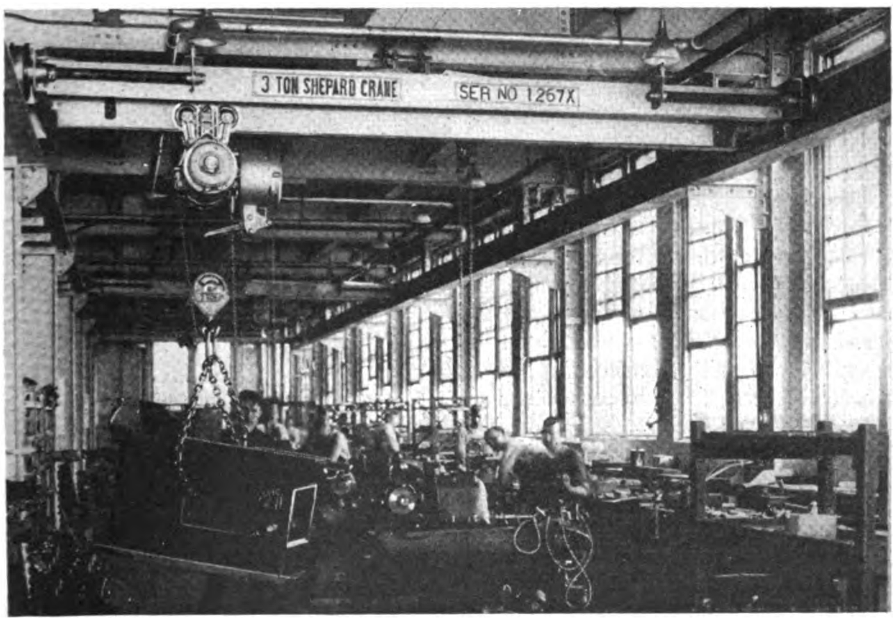


Fig. 2—A department arranged for a progressive method of assembly.

The machines progress along from one man to another as the various parts are added. This department is on the main floor under the balcony. Five 1-ton and two 3-ton Shepard floor-operated cranes, in addition to Elwell-Parker electric trucks and Stuebing hand-lift trucks, are used to handle the work.

The working space under the balconies is lighted by 200-watt lamps in Holophane reflectors spaced on 10-ft. centers. This arrangement produces an average intensity of 12 to 15 foot-candles on the working plane. The main central bay is lighted from 23 1,000-watt lamps in Holphane No. 661 reflectors mounted in the saw-tooth ceiling above the cranes. These lights are placed on 20x30-ft. centers and staggered; that is, two lights are placed in a saw tooth and one light centered in the next, and continuing with two-and-one sequence. With this arrangement an average intensity of 8 to 9 foot-candles is produced at the working plane. These intensities represent the best practice for the types of work involved.

The average monthly power consumption, since the plant has been under normal production operation, has been as follows:

Power and light, a.c.	29,690 kw.-hr.
Power, a.c.	15,540 kw.-hr.
Light, a.c.	14,150 kw.-hr.
Power, d.c.	13,500 kw.-hr.

This represents approximately an average hourly load of 75 kw. for a.c. power and 65 kw. for d.c. power. The maximum combined maximum-demand rate since the plant has been in operation is 241 kw. This would leave about 101 kw. as the average

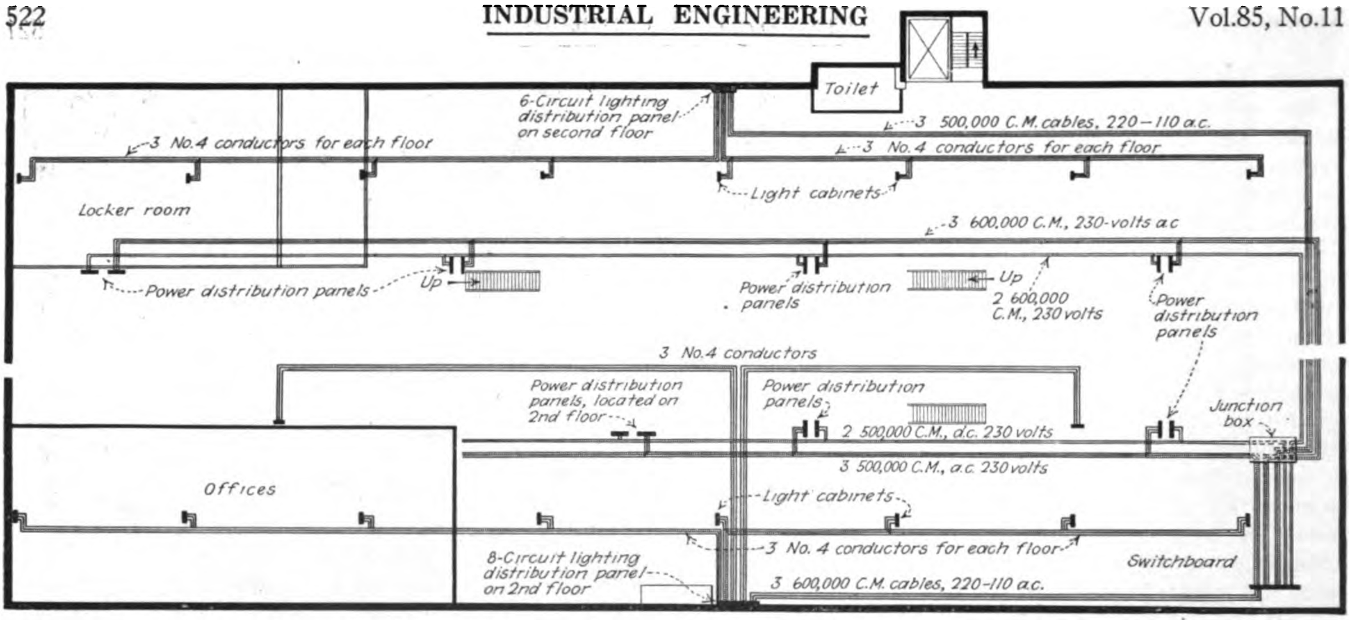
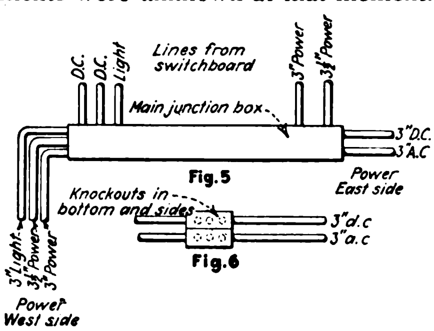


Fig. 4—Elementary line diagram of power and light circuits.

lighting load used by the entire plant.

Provision is left in all power boxes and also in the distribution line for expansion and the connection of additional equipment. The average load is but 60 per cent of the rated full-load capacity of the distribution system.

In laying out the power system the probable consumption was based on the current density rate as disclosed by the most densely machined section of the Cincinnati Milling Machine Company. If the new plant should become as densely machined there would thus be sufficient room for power expansion. This gave a density of 2.6 to 3 watts per sq.ft. of working area. Further analysis of the machines required for production indicated that an equal amount of alternating and direct current would be required, with the possible growth in the direction of alternating current. The system was therefore designed on this basis inasmuch as the exact motor requirements were unknown at that moment.



Figs. 5 and 6—Sketches of two features of the distribution system.

The upper sketch, Fig. 5, shows the arrangement of the main junction box for the distribution of power and lighting current. Three a.c. and two d.c. feeders extend from the switchboard to this box. The feeders for the east and west sides of the building are taken off from the ends of this box. This is used as a pull box and is a convenient means for eliminating fittings in a difficult place to work. Special a.c. and d.c. outlet and pull boxes, Fig. 6, lower sketch, are placed every 20 ft. for convenience.

These estimates indicated that 150 kw. of a.c. power and 150 kw. of d.c. power would probably be the maximum requirement. The feeders to the two sides were, therefore, calculated on this basis, allowing a liberal factor of safety in determining the size of the a.c. lines. In determining the sizes of lines such sections were selected that would pass the Underwriters' requirements and in addition, reduce voltage losses to a minimum.

In determining the supply mains, provision was made for future building expansion and additions. The two 800,000 circ.mil circuits on the d.c. supply lines (originally installed for the former supply system) permit of approximately 250 kw. load; therefore, sufficient expansion is allowed in this direction. The three-conductor No. 2 high-tension cable at 13,200 volts and a power factor as low as 0.75 provides for 1,550 kw.; therefore, sufficient expansion is also provided here. The transformers were likewise installed on an exchange basis, in the event of future expansion. The system is, therefore, considered to be flexible enough to take care of probable needs in the future.

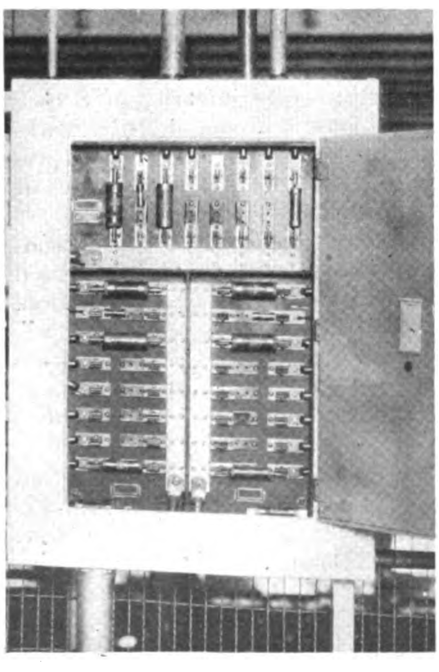
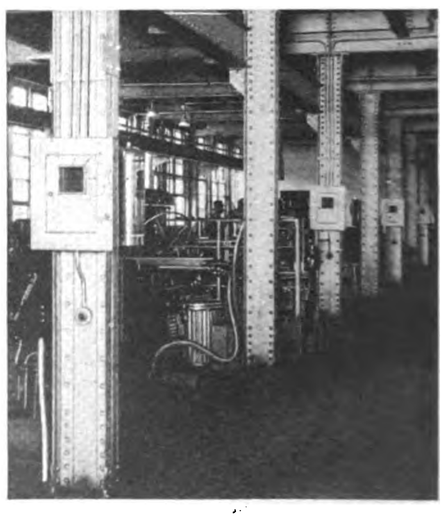


Fig. 7—One of the alternating-current power cabinets.

These Trumbull cabinets are provided with slate barriers between the copper buses to prevent flash-overs. This section of the plant is not heavily machined but sufficient provision is made in all sections so that machines can be added as desired without revamping the distribution system.

Fig. 8—General view of the lighting cabinets in the tool department.

Each cabinet is of the dead-front type with tumbler switches controlling 16 200-watt lamps in Holophone reflectors, mounted on 10-ft. centers. A plug receptacle for an extension cord or small portable tool is placed beneath each cabinet. This department is completely equipped with individually driven Cincinnati plain and universal milling machines.



Long-Time Guarantees of Prosperity

By EDWARD J. MEHREN
*Vice-President,
McGraw-Hill Publishing Co., Inc.,
New York, N. Y.*

I HAVE elected to speak today on prosperity. It is one of our most active topics. Can we maintain it? Can we go to ever higher levels? Or have we reached the top and must we soon retire to less active business and a lower standard of living?

There are obviously many factors in making prosperity, and if exact definition be insisted upon, one must admit that there can be no absolute guarantee of unbroken high-speed business. But there are certain fundamental factors so deep and broad in their influence that there seems no better synonym than the word I have used.

America's Production

To begin with, let us get a picture of America's recent industrial development. The last U. S. census of manufactures showed that the volume of our manufactured goods in 1925 was $2\frac{3}{4}$ times that of 1899, but that the number of men employed was only 1.8 times as great. In other words, there has been a great increase in output per worker; in fact, each man now produces 50 per cent more than he did in 1899. The reason is that we now use $3\frac{1}{2}$ times as much power as we did 28 years ago. We have transferred the work of industry from the backs of men to the inanimate forces of steam and electricity.

As a result of the use of power and machinery, therefore, 67 men now do as much work as 100 men did before.

Where have gone these men thrown off as surplus labor by the older industries? The answer is that they have gone into new industries and are making products undreamed of in 1899. That important phenomenon is at the bottom of our prosperity.

In this absorptive power, in this receptive power, lies the fundamental secret of American prosperity. We have a market of extraordinary receptivity and adaptability. To us that no longer seems remarkable. We live with it. It seems as though it could not be otherwise. But it is extraordinary, truly a wonder. For contrast, look at the Old World, with its lower level of receptivity and its inevitably lower standard of living. So did their father; so will they do. As a result, while the European merchant fights feverishly for foreign trade, a market of tremendous potentiality—the home market—lies undeveloped at his very feet.

Edward J. Mehren

Developing Receptivity

The first long-time guarantee, then, of prosperity is the preservation of this adaptability and receptivity of the American people. The primary means of preserving it is to continue to raise the level of intelligence of our people, and this demands a continuance of liberal support of our educational system. A second means of preserving this receptivity is to give the public an opportunity to exercise this faculty. If they never have anything new, they will be content with the old. We must expect, yes, we must foster, a continuous increase in the purchasing power of both the salaried and wage groups.

Here, then, we find a market of remarkable receptivity. It is obvious that we must supply it with more staples and particularly with new goods. Design of present goods must constantly be improved, but that is not sufficient. We must go behind the design room; we must go to the research laboratory, where radically new products and processes are discovered. *There* we will find, rather than in the design room, another long-time guarantee of prosperity.

I make no apology for pleading with you, bankers, industrialists, merchants, for bounteous support of research. You are building for the future. It is your hope that the businesses you are rearing will pass in vigor to your business heirs. I hold out to you a promise: future industrial success—if you employ research, and I hold out a threat: industrial lameness and decay, if you neglect it.

Purchasing Power

So now we have two long-time guarantees of prosperity: First, the maintenance of a receptive market, and, second, research for the creation of new products. Then what? Obviously, the receptive market must be able to buy the new products as well as more of the old. That brings us to the question of purchasing power.

It should be evident that if we merely maintain our present purchasing power we cannot take new goods in addition to the old we are absorbing today. It is absolutely necessary, therefore, that the public's purchasing power must constantly grow larger. The old grumbling against an apparently too prosperous salary and wage group must give way to the appreciation that well-paid workers are good customers, and that good customers keep the factory wheels moving. Aye, more, a halt in the increase in purchasing power will bring industrial distress, for it would then be impossible to absorb into new industries the men released from the old.

There are two ways of increasing purchasing power: First, by reducing prices so that the present salary and wage dollar will buy more goods, and, second, by increasing the number of salary and wage dollars. We are using both methods in this coun-

Abstract of an address before the Chicago Association of Commerce, Oct. 19, 1927.

try. Improvement in management, elimination of production wastes, simplification of varieties in all manner of products, standardization of materials and parts and last, but not least, research—all these are mechanisms that we are applying, and that lead to lower production costs, lower selling prices and constantly higher purchasing power of the dollar.

In addition, we have increased the number of salary and wage dollars faster than the increase in the cost of living. More and more we are abandoning the theory of the "living-wage." We believe in something more liberal, in what I call a "security wage," a wage that provides not merely a decent living, but enough margin to own a home, to educate the family, and lay up savings that will secure the worker against the fears of unemployment, sickness and old age. To make such provision for himself and his family is the natural ambition of every healthy-minded man. To be content with less is to reduce one's self to a definitely inferior social order. To be content with less is to accept dependence rather than freedom, and freedom, economic as well as political, is the proper ideal of every American.

An additional, large advantage of having well-paid salary and wage earners, is the industrial co-operation that results. Well-paid workers, under wise leadership are ambitious, saving and contented, and help reduce production costs. The combination of such workers, fair-minded capital and efficient management, make an impregnable industrial system.

Flow of Goods to Market

The next step after increasing purchasing power is to provide for the economical flow of goods from the manufacturer to the public. Manufacturing economy requires mass production, and mass production requires mass distribution. Here we come back to research. The area for the recovery of wastes in distribution is possibly larger today than in production, but it will yield economies only by experiment, study and research. The field is tremendous and again I plead for your generous support of research, this time of research in distribution. Further, I would let modesty and restraint do you an injustice did I not point out the need for still wider understanding of that "sword arm of business," advertising, which creates wants and mass demands, and is the channel through which knowledge of new products becomes known to the buying public.

The Circle

We have then, this recurring sequence: we use continually more power and machinery, and as a result increase the output per worker. This, in turn, has two effects: first, it increases the workers' earnings, and, second, because fewer men are needed throws off a surplus of labor. This surplus must, then, find employment in new industries whose product will be bought by the workers whose earnings have been increased. The crux of the situation, then, is to continue to increase the output per worker and to find new products to absorb the surplus labor thrown off by the older industries.

The process obviously proceeds in a circle, but in an ever widening one. We increase output and earnings per worker and create a labor surplus. This surplus is absorbed by making new products which are then sold to the workers whose purchasing power has been increased.

Naturally, there are other factors that affect our prosperity. I have mentioned two of them—the receptivity of our people and the effective use of advertising as a means of creating demands. There are many others. Their discussion in a short address would be confusing, even if possible. Those I have chosen, though, are fundamental. Their understanding will go far to keep up a general upward trend, even though from time to time there may be recessions, even as the one we seem to be going into just now. I hold out no panacea, no guarantee against occasional recessions. My subject was deliberately chosen as the long-time guarantees, and the fundamentals I have developed seem to me to deserve such description.

Fortunately we have a number of agencies that are helping and that supplement individual and corporate effort. They will go far to safeguard us if we know how to use them. I refer, first, to the trade association; second, to government departments; third, to the universities; and, fourth, to the business press. Of the trade association I need hardly speak. Its service in fostering sound trade practice, encouraging research and carrying on joint propaganda are of the very marrow of American business. It forms an excellent agency for joint research when one group of laboratories can serve all, or when individual businesses are not "sold" on separate research activities. Of the government departments, let me recall the service of the Bureau of Standards and the Bureau of Mines, and particularly of those newer bureaus developed under that extraordinary business statesman, the present Secretary of Commerce.

The universities make a contribution all too little appreciated. The industry that lacks contact with the university today is doing itself an injustice. There they have in the making the business men of tomorrow, your successors. There they have a fine enthusiasm for research—typified in a splendid way by the Engineering Experiment Station of your own State University—the University of Illinois—which, I am proud to say, is my own Alma Mater. They are studying distribution with the advantage of detachment from the drive and the detail, and are trying to deduce laws that will help you and me.

There is finally the business press, which is business articulate, the instrument for welding all phases and branches of each industry or trade into a harmonious, homogeneous whole. It is an agency for interpreting business, its trends and problems, to business itself and other groups of the community. It is a medium for exchanging ideas on these vital problems I have discussed, cost reduction and research, and finally, it is the chosen instrument for clarifying, crystallizing and expressing the ideals and objectives of industry and trade.

Conclusion

If, then, the discussion we have gone through together be sound, it is the responsibility of every American business executive to give generous support to cost reduction efforts and to industrial and scientific research. They must have faith in the receptivity of the American people and a knowledge of the use of advertising to take advantage of that receptivity. Above all they must support research in their own corporations, in trade associations and in the universities. We will most certainly continue to increase our industrial capacity. If we fail to discover new products at a rate sufficient to absorb surplus labor we shall have to divide the fruits of industry between a larger number of workers, our purchasing power will decline and our standards of living drop to lower levels. If we can find new products at a sufficient rate we shall be able to absorb the surplus labor and continue our upward march.

Prevention of High-Voltage Hazards in Industrial Sub-Stations

By WALTER C. WAGNER
The Philadelphia Electric Co., Philadelphia, Pa.

WITH THE increasing tendency of industrial plants toward purchase of high-voltage power a new safety problem is brought into the plant. In many cases the plant operators are familiar only with the more common low voltages and need advice on the safety features necessary in operating the high-voltage equipment. The following is an abstract of some of the more important points, as seen by the supplier of the power, from a paper delivered before the sixteenth annual safety congress, which was held at the Stevens Hotel, Chicago, Sept. 26 to 30.

The necessity of low first costs and operating expenses requires the absolute minimum of installation, operation and maintenance costs, compatible with the safeguarding of man and maintaining the proper degree of service continuity. The paper briefly reviews some present problems, indicates progress of a few recent developments, and outlines the trend of rules and regulations upon which to depend for guidance. The problems may, in general, be divided into groups, according to the development of the works.

Studies of Design Layout

In the preliminary study and design period, joint effort is often required to secure proper housing conditions for substation receiving equipment and conductors. The industrial man responsible must actively join with the representatives of the supplier in studies of physical conditions, the analysis of the customer's operating requirements, and contribute in matters such as those relating to exposures, ventilation, illumination, accessibility, guarding and clearances.

It has been found good practice to require the signature of the safety engineer on all design drawings before they go into effect. This assures greater uniformity in design, and provisions for changes due to new conditions arising, such as, protection from fire streams, blanking off ventilation or exits, or other obstructions, loss of illumination, inadequate grounding, or the proximity of unnecessary amounts of combustible materials.

It is in the design period that maintenance features must be incorporated, these varying with operating conditions. Will operating conditions permit killing of all service lines and equipment, or must additional clearances, isolation or guarding be considered? Where continuity of service is paramount, the alternative of the spare unit must be balanced against other methods which will insure adequate protection to the customer's and company's maintenance men, assure continuity of service, and minimize the duration of interruptions.

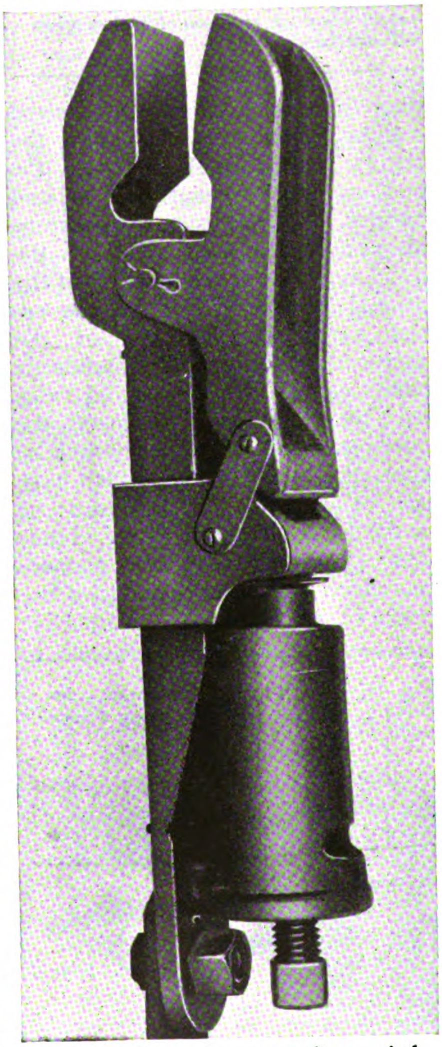


Fig. 1—Clamp for grounding switch terminals in 13.2 kv. oil switch truck.

To operate this grounding clamp place handle (above) in socket to engage ½-in. bolt. Turn the handle to the right and the bolt forces the wedge against the movable clamp, thus closing the jaws. To release the clamp, turn the handle to the left.

Safety equipment is necessary. It has been the practice of some electric power companies to furnish, among other articles, a pair of rubber gloves, and later to inspect and maintain them. Experience has shown that the reliability of rubber gloves cannot always be determined by handling or visible inspection. It is advisable to request the customer to purchase and install rubber gloves initially, to maintain them, and to have them tested at frequent intervals.

An improvement of design of switching apparatus for the more important customers is found in the development of the truck-type switch. These trucks have complete enclosures of light sheet steel, whose switch mechanism, together with related equipment and wiring, is killed by withdrawing the carrying truck from the enclosure.

Safety in Construction

A solution of the problem of providing a proper grounding clamp to ground the switch terminals in the enclosure is shown in Fig. 1. Problems still remain concerning the best method of installing and isolating potential transformers and of gaining quick access to switch parts.

Indicators for the position of all high-tension oil switches have been slowly developed. One company uses the terms "open" and "closed" for its markings, Fig. 2, but recently an interruption to service was prolonged because a new man, an old steam engineer, thought that the word "open" as applied to the case of a steam valve, meant a flow of energy, and "closed," an interruption of the flow. Manufacturers quite generally use the terms "off" and "on." The method

of grounding, consistent with the larger use and greater importance of power supply, is, in general, to have multiple grounds connected by sweating to the common substantial copper ground bus at different points. In some instances even lightning arrester grounds are now being connected to the common grounding network at very large industrial substations in order to reduce the ground resistance to the minimum, but this should not be done where a hazardous rise in potential may develop.

During the construction period, neglect to insist on the removal of all but the minimum possible amount of combustible material has caused serious fires. It has been found advisable, at times, to require an extra extinguisher, particularly during temporary construction periods.

Maintenance and Operation

From the operating standpoint, company responsibilities actively begin with the introduction of current. Every effort should be used in aiding the customer, such as making personal contacts with the prospective operator of the substation, and the installing of glass-covered or varnished-surface single line circuit diagrams and operating rules. First-aid prone-pressure resuscitation must be discussed, and if practicable, a lesson given to the men in the presence of their employer. With the employer interested, a labor turnover is less likely to lead to a loss of these instructions by the new men. The practice of making use of every electric utility employee visitor to the customer's substation, such as the meter reader, the meter tester, and the maintenance man, to advise of any unsafe conditions is to be commended.

In testing equipment to determine whether it is alive, no maintenance work should be allowed until a double check on the dead circuit is made. The neon gas-filled tube at the end of a switch hook, Fig. 3, has been extensively used but the necessity of opening a compartment for accessibility to a known live part, in checking the integrity of the tube, is an unnecessary hazard. One company is now installing a Ford coil by which this tube can be safely lighted before and after the test of the supposed dead section, thus making certain that the tube has been operative during the test. A metal switch-hook terminal with condenser has also been used to advantage, utilizing the spark discharge as an indication.

It is of course necessary to be an

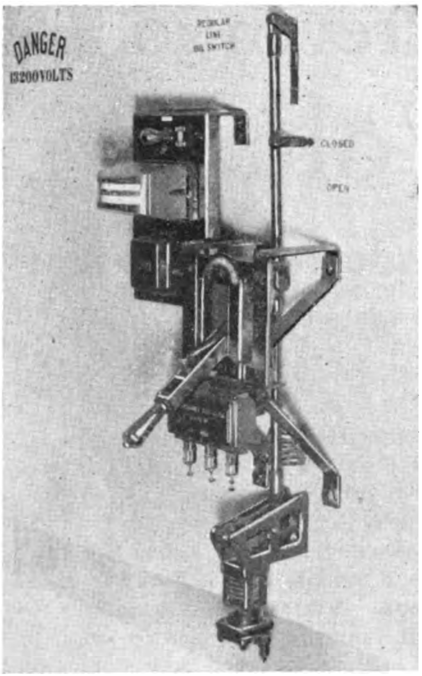
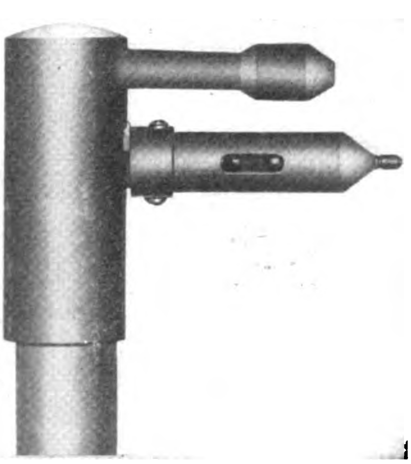


Fig. 2—One method of marking indicators showing position of high-tension oil switches.

authority on all safety rules required by those having jurisdiction in the territory served, and to know the trend of developments in related activities. Many state regulatory bodies and others are waiting for the formal approval of the revision of the National Electrical Safety Code revised under the auspices of the American Engineering Standards Committee. Many of the old rules have been changed to meet the modern practice, and it is advisable to secure copies of the rules which have been printed by the Bureau of Standards, Washington, D. C. Handbooks of most interest in this connection, which have been issued by the Bureau of Standards, are as follows:

Fig. 3—Switch-hook with neon gas-filled tube at the end for testing equipment to see if it is alive.



Handbook No. 6—"Safety Rules for the Installation and Maintenance of Electrical Supply Stations"; No. 7—"Safety Rules for the Installation and Maintenance of Electric Utilization Equipment;" No. 8—"Safety Rules for the Operation of Electrical Equipment and Lines"; No. 10—"Safety Rules for the Installation and Maintenance of Electrical Supply and Communication Lines." It is recommended, in the absence of other rules or in the face of existing local rules, that operators urge the adoption of these revised National Rules.

Complex Conveyor System

(Continued from page 508)

from being fed onto the belt when not moving. It is obvious that depressing the stop button of *PB2* at any time would disconnect control line *CL1* from *SL3*, thereby causing switch *MS1* to open and this in turn would break the circuit of *SL3* to the other two switch magnet coils, opening those switches in almost the same instant.

As to the use of the switch *PB3*, which was another addition of necessity, this was installed to permit operation of the two belt conveyors without the elevator. To start up only the two belts, it merely required pressing the start button of *PB2* to close switch *MS1* and upon releasing this button *MS3* would immediately follow. Although it was impossible to accidently start up the elevator motor *M2* with *PB3* in this position, a rule was established to always remove the thermal plug fuses of the motor on any unit being repaired as an extra safety precaution.

The switches used in this installation were all standard and no changes had to be made except in the methods of connecting up the fuses and contact points. The magnetic switches are G. E. Co., type *CR 7005-D4* with thermal plugs of the proper rating for each motor, using fusible link cat. No. 167539. The main stop and start pushbutton station is also a G. E. product; Cat. No. *BS212-A*, as well as *PB1* and *PB4*, which are of the momentary contact class but with circuit normally closed. Limit switches *AS1* to *AS4* are of Cutler-Hammer make, with the usual roller wheel replaced by an extension arm with a reverse bend as shown. Although these were a two-pole type of switch, it was only necessary to use but one side of each.

Types and Functions of OVERLOAD RELAYS

By H. D. JAMES
Consulting Control Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

PREVIOUS articles in this series on control equipment which have already appeared in INDUSTRIAL ENGINEERING, have discussed the importance of application, functions of operation and the considerations that influence the design of arc-rupturing devices. Another point, however, of equal importance, is that of the selection of the relay devices that provide protection to the motor.

The requirements for overload protection of electric motors may be divided into two groups:

(1) Protection against accidental conditions of the circuit such as a short circuit, ground or some very abnormal operating condition. Protection against this type of overload is usually afforded by the same device that protects the feeder supplying power to the motor. These feeders are usually protected by an approved fuse which is capable of rupturing abnormal overloads as well as being of a suitable size to protect the feeders from overheating with normal overloads. The size of the fuse suitable for each size of feeder is given in the National Electric Code issued by the National Fire Protection Association.

Large feeders may be protected by circuit breakers instead of fuses. The National Electric Code gives all of the detail information necessary for selecting such overload protection and need not be discussed in detail in this article.

(2) Protection against normal operating overloads. A motor may be overloaded sufficient to cause overheating and a rapid aging of its insulation without taking enough current from the line to open the feeder protection. The motor has considerable thermal capacity so that short-time overloads may not cause undue heating. The same is true of control apparatus and other equipment connected in the motor circuit. The kind of protection required for the motor depends a great deal upon the application. The simplest problem consists in protecting motors operating on a continuous load. If the motor is applied to an intermittent load it is usually for short periods of time which are limited by the process of application and, therefore, we are only interested in keeping these peaks within definite limits assuming that if this is done the motor will not be dangerously heated.

Coil and Plunger Relays—The controller has a circuit closing device which may be a magnetic contactor or a manual switch held in the closed position by a low-voltage magnet. In the event of a continuing overload, a relay opens the circuit to the coil of the contactor or low-voltage magnet and disconnects the motor from the source of power.

The most common form of relay has been an electromagnet of the coil and plunger type provided with an oil dashpot which introduces a time element so that the relay would not open its contacts during the starting period of the motor or on very short time overloads. The tripping value of the relay can be adjusted by changing the air gap in the open position of the plunger. The calibration is expressed in amperes and some means provided for locking the adjustment when made. Wider ranges of adjustment are made by changing the series winding or relay coil. Relays of this type are illustrated in Figs. 1 and 2 on page 528. They are generally well understood and the descriptions under the illustrations seem sufficient.

This is the fourth article of a series in which Mr. James is discussing the functions of control equipment in the operation of motor drives, and describing the construction and operating principles of the types of such equipment in industrial use. The first article which appeared in the March issue dealt with the general application of control equipment. The second article in the May issue covered the functions of control. The third article in the September number described arc-rupturing devices. The fifth article of this series will appear in an early issue.

During the last year or two, the practice of starting squirrel-cage induction motors by connecting them to the full voltage of the circuit has changed from a maximum of 5 hp. to 50 hp. and larger in some cases. The 5-hp. motor accelerated to full speed in a very few seconds, so that a fuse or dashpot type of relay was reasonably successful for such applications. Larger motors require more time to accelerate and consequently introduce a new problem in overload protection. When these larger motors were started on reduced voltage the relay was inoperative during the starting period; when the motor was transferred from reduced voltage to full voltage the relay became operative but the overload during transfer was of such short duration that the dashpot relay or even fuses proved satisfactory. If the controller provides a starting and running position the relays can be connected so that they are not in circuit during the starting period even though the starting may be at full voltage, but this additional point seems unnecessary for full-voltage starting and is only used when a suitable relay is not available.

In order to meet this new demand for overload protection a new form of relay was developed commonly called the thermal relay. The usual form of this relay particularly for the smaller motors consists in the thermal responsive element and a heater, whose temperature is directly proportionate to the current. This heater may be a small resistor in series with a motor, or a heater may be used for a.c. circuits which depends on the induction in the iron of

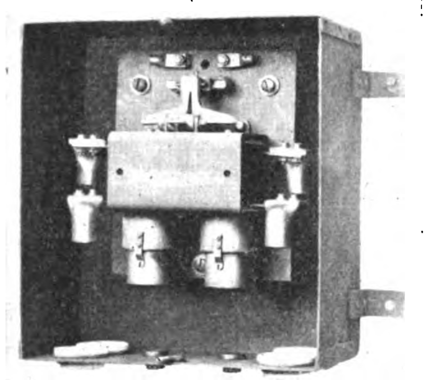


Fig. 1—Overload relay of the coil and plunger type.
This *KN* relay shown is for use with polyphase motors and it has two overload elements operating a single contact. Its operation is the same as the *AB* relay in Fig. 2.

a magnetic circuit. A number of illustrations, therefore, are shown of different commercial designs.

These relays, therefore, may be divided into two classes dependent on the type of heat responsive means used. They are: *(1)* Bimetal Relays and *(2)* Fusible Alloy Relays.

Bimetal is a name given to a metal strip or sheet made by rolling together two dissimilar metals having a considerable difference in their temperature coefficients. If a strip of this material is heated it will bend due to one metal expanding more rapidly than the other. Relays of this type make use of the bending or deflecting of a bimetal strip to open or close a contact. For motor protection the contact is usually opened. The motor current may be passed through the bimetal strip and heated directly or the heat may be transferred to the bimetal strip from a resistor in series with the motor. Manufacturing difficulties result if current is passed through the bimetal strip as this requires a different cross-section of bimetal for every ampere rating. It is better practice to make the bimetal of the same section and arrange the rating of the relay by making different heater elements. Each relay is usually provided with means for adjusting its tripping point, over a limited range. An adjustment from 80 to 120 per cent of the heater rating is quite common.

The bimetal strip deflects slowly under the influence of heat. This may cause bad action on the relay contacts so that most relays are designed to provide for a quick make and break of the contact or take care of this condition in some other way. The different methods are stated under each illustration and a brief description follows.

The overload elements of the type *TC-221* relay shown in Fig. 3 consists of two parts:

(1) A heater coil enclosed in a cast shell which gives the relay increased thermal capacity. This heat is communicated to a bimetal element which deflects and opens the relay contacts.

(2) The bimetal element which is in shunt to the heater coil passes a small part of the motor current directly through this element, which contributes to the heating of the bimetal strip but under ordinary load conditions is not sufficient to open the contacts. If a short circuit occurs the current through the bimetal strip will be sufficient to open the relay contacts before the heater coil is injured. This relay can be obtained both single-pole and double-pole and can be given sufficient thermal capacity so that it has the same time temperature curve as the motor with which it is used.

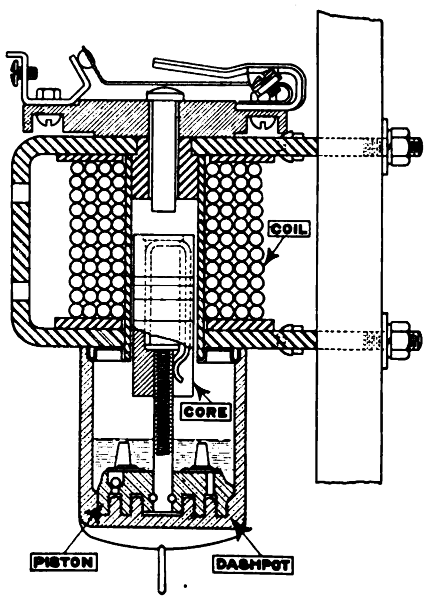


Fig. 2—Cross-section view of coil and plunger-type, overload relay.
The time element in this *AB* relay is obtained by an oil dashpot, which retards the tripping of the relay. It is arranged with a valve to permit quick resetting. Fine adjustments are obtained by raising or lowering the plunger in its open position.

Two heater elements are used in the type *TC-121-C* relay shown in Fig. 4, one connected in each of two leads. A strip of thermostatic metal is mounted directly above each heater, also a contact mechanism which is held closed by the thermostatic strip when in the normal position. When the motor is overloaded, the heat from the heater unit causes the thermostatic strip to deflect to such an extent as to allow the contact mechanism to trip and disconnect the motor from the line. The rating of the relay is in amperes and is changed by changing the heater elements. An adjustment is provided for each element of the relay so that the latch will trip from 80 to 120 per cent of the heater rating.

In the *Thermaload* relay, which is illustrated in Fig. 5, the overload element consists of a bimetal strip wound in the form of a spiral, the lower end of which is anchored. The upper end is free to move. On overload the upper end of the spiral lifts the arm of the relay, located between the two spirals, sufficiently to separate the relay contacts. By referring to the line diagram in Fig. 6, it will be seen that two contacts are used, the one that opens first is in series with the pushbutton that closes the magnet contactor. The second contact is in series with the interlock that holds the contactor closed. After the second relay contact is opened the contactor opens, but cannot again be closed by the pushbutton until the bimetal has cooled sufficiently to close both contacts. This insures the contactor being closed in a positive manner after the pushbutton circuit through the relay contact has been established. The relay is normally made with two overload elements, one for each of the two leads to a polyphase motor.

Likewise, the *TA* relay is ordinarily made with two overload elements for use with polyphase motors. The two bimetal strips engage a common insulated rod which is lifted

Fig. 3—Bimetal-type thermal overload relay for protection of a.c. and d.c. motors having a rating of from 20 to 300 amp.
This *TC-221* relay has two overload elements, one connected in each of the two motor leads.

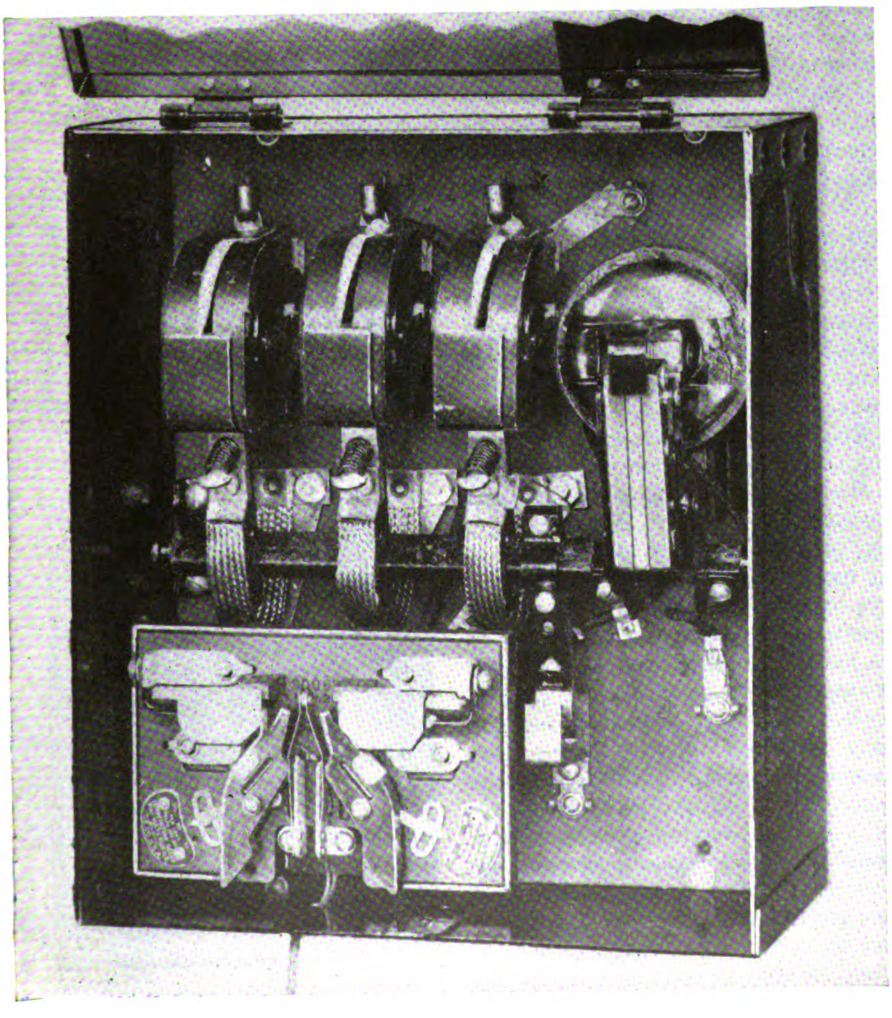
when the bimetal is heated by small resistor elements, which are located immediately beneath their respective bimetal strips. On overload the bimetal lifts the insulated rod sufficient to release the catch which permits a spring to open the relay contacts. After the bimetal has cooled the relay contacts can be reset. An adjustment is provided for setting the relay to trip at 80 to 120 per cent of the heater rating. Heaters can be provided up to 95 amp. in capacity, but above this value inexpensive series transformers are used.

Relays for polyphase a.c. motors usually have overload protection in two phases accorded by two separate heaters and bimetal strips, but often one set of contacts.

Fusible Alloy Relays—The heat-responsive element in this group of relays shown in Figs. 9 to 11, consists of an alloy similar to solder, which melts at a very definite temperature. When hard, this alloy holds the relay contacts closed against a spring tension. Heat is applied by means of a resistor or an inductive device in the motor circuit. When the load produces enough heat to melt the solder, the spring revolves a pin embedded in this alloy and moves the relay contacts to the open position. As soon as the alloy solidifies which it does very quickly after the load has been removed, the relay can be reset. These relays are sometimes called the solder-pot type. A brief description of three different relays of this general type follows:

The *I-C* thermal relay is a two-pole type with a common contact member as shown in Fig. 9. The alloy is contained in a cup or cylinder into which extends the stem of a ratchet wheel. This alloy is heated by a resistor element which is in series with the motor, so when an overload occurs the heat from the resistor element gradually raises the temperature until the alloy is melted. This permits a ratchet wheel to turn and release the mechanism which opens the relay contacts under spring pressure, and as soon as the alloy solidifies the relay can be reset. The rating of the relay is easily changed by changing the heater.

Fig. 4—Motor starter equipped with bimetal-type relay.
This *TC-121* relay has a maximum rating of 80 amp. and is suitable for use with motors up to 50 hp. in capacity.



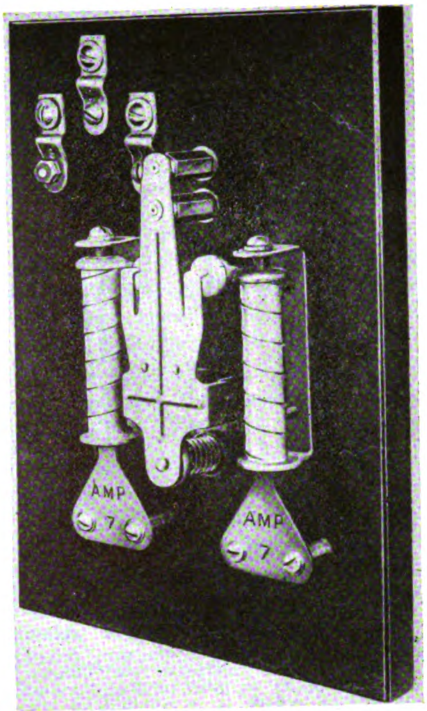


Fig. 5—A spiral-wound, bimetal-type overload relay.
In this *Thermaload* relay, a small resistor for heating the bimetal is inserted inside the spiral making a very efficient heating device. The calibration of the relay is changed by changing the heater elements.

In the *C-H* thermal relay Fig. 10, two heaters are associated with two thermal elements. The heaters are connected in separate motor leads. The thermal element consists of a stationary tube which encloses a spindle, the two being held together by a thin film of fusible alloy. When the motor is overloaded, there is sufficient heat to melt this allow and release the spindle, which rotates under the action of a spring and trips the relay contacts. The operation of either or both of the thermal elements trips the same set of contacts. The relay contact can be closed as soon as the fusible alloy hardens. The current at which the relay trips, can be adjusted over a 20 per cent range. This is obtained by varying the position of the cover carrying the thermal member with reference to the heater. Greater variations in tripping current are obtained by changing the heater coil.

The *A-B Inducto-therm* relay, however, differs from all other thermal relays in that the heat, causing the relay to trip, is produced by induction. The relay as shown in Fig. 11 is essentially a transformer, the primary coil of which is in series with the motor lines and the secondary is a copper element of one turn. The heat in the copper element or heater is due to current and resistance, the

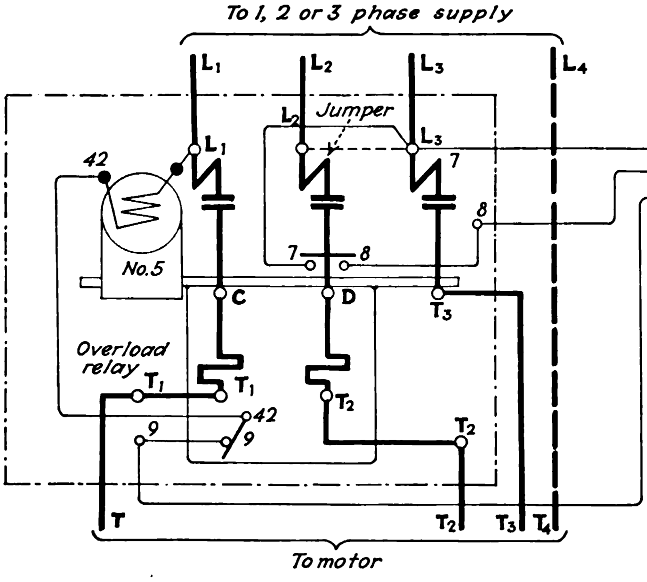


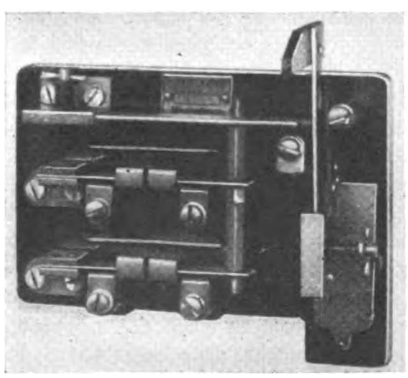
Fig. 6—Connection diagram of linestarter controlled by the "TA" relay.
The above connection diagram refers to the thermal overload relay shown separately as a unit in Fig. 7 and in Fig. 8 where it is applied in the enclosed type of commercial linestarter.

current being produced by magnetic induction. The magnetic flux linking the primary and secondary of the transformer is varied by moving an adjustable core which increases or decreases the air gap. The core, which is an iron screw, is readily adjusted, thereby providing a means for setting the relay to currents of motors of different horsepowers.

Relays for Larger Motors—The parts of these thermal relays which carry the motor current are small, and their maximum current rating is limited. When used with motors in excess of this rating some inexpensive form of series transformer is used. If the relay contact is not sufficient to handle the control circuit for these large controllers a small contactor can be used between the thermal relay and the main control circuit.

These relays will carry the rating stamped on the heater, increased by whatever adjustment is provided and will successfully withstand overloads up to 600 per cent of the heater rating, but the ordinary type of thermal relay must be protected by a fuse as it takes time for the heat to be transmitted from the resistor to the bimetal or alloy. Therefore, when a short circuit occurs the heater would be destroyed before the bimetal or alloy had time to respond, if it were not protected by a fuse. This fuse is ordinarily required for protecting the motor feeder and does not add expense to the equipment.

Fig. 7—Bimetal type *TA* thermal relay with two overload elements for use with polyphase motors.



Long-Time Thermal Relays—The relay ordinarily furnished for the general purpose motor may have a time element represented by 30 sec. to 30 min., depending upon the design and the percentage of overload ordinarily guarded against. Large motors have considerable thermal capacity and require several hours of considerable overloads to raise their temperature to an unsatisfactory value.

Relays are available which have a time element approximately as long as the motor. A relay of this type is illustrated in Fig. 3. Engineers differ, however, in their opinions as to the most desirable time element in relays of this kind. If the relay has a time-temperature curve the same as the motor it will permit the motor to be operated at its maximum output. If this output is exceeded and the relay functions, it will take a corresponding period of time for the motor to cool off and the relay to reset. A relay having a shorter time would ordinarily be set to operate before the motor reached a dangerous temperature and serve as a warning that an overload is being carried. It would be safe to reset such a relay in a shorter time than would require the motor to cool off depending upon the time element of the relay itself compared with that of the motor. If a relay is used having a long time element its performance should be carefully checked against the feed wires and control equipment and this part of the equipment selected of sufficient size to safely carry the load within the

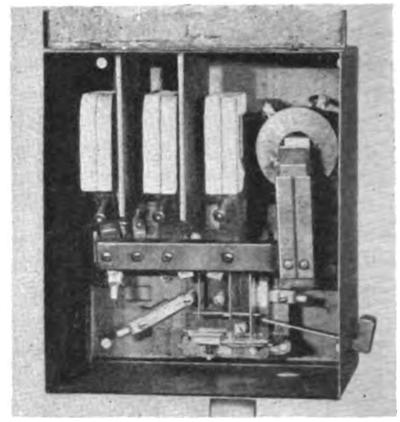
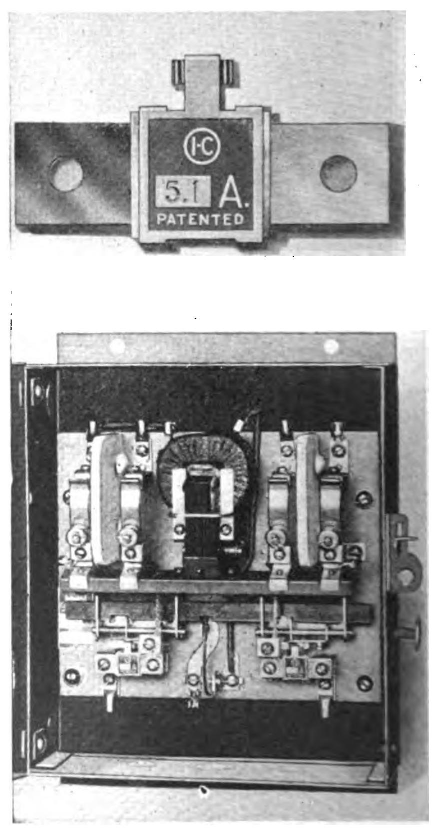


Fig. 8—Inclosed linestarter equipped with thermal overload relays.
The type *TA* relay contacts are reset by hand with the device at the right after the bimetal has cooled.

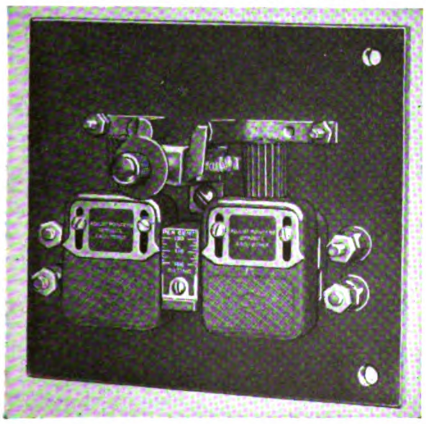
Fig. 9—Fusible alloy-type relay and its application in an automatic starter.
The relay shown at the top is a two-pole type with a common contact member. The alloy is contained in a cup or cylinder into which extends the stem of a ratchet wheel. In the lower view the relays are shown in each of the two motor leads.



tripping value of the relay. The advantages of a long-time overload relay can best be determined by experience. There are a number of problems in connection with thermal overload relays which will be worked out as our experience with this apparatus broadens. For many applications a relay with sufficient time element to start the motor up, when set close to the full load motor rating will prove satisfactory.

Thermal Cutouts—A discussion of the overload protection of motors would not be complete without mention of the thermal cutout. This fuses a current carrying member due to an overload in the same manner as a fuse, except that the cutout develops either part or all of its heat. A resistor winding which communicates the heat to the fusible member introducing a time lag which is much longer than that obtained with the ordinary fuse. Cutouts are available which have a sufficient time lag to permit the starting of induction motors at full voltage with cutouts that have a continuous rating not much in excess of the full-load rating of the motor. When a cutout opens the circuit, it is necessary to dismantle it and renew the fusible elements. For these reasons they are not as convenient as overload relays but are very suitable for manually-operated starting switches which do not have a low-voltage device which can be open circuited by a relay. Relays can only be applied to motor starters and controllers which have means for opening the main circuit when a small magnetic circuit is opened, such as magnetic contactors and low-voltage devices. When thermal cutouts are used the starter should be inclosed and should be operated from the outside. The starter should be so arranged that access cannot be had to the cutouts unless the starter is in the off position. When the inclosure has been opened to give access to the cutouts, the starter should be rendered inoperative until the inclosure has been restored. These are the same requirements as for fused switches on 150 volts and higher and are necessary for the protection of persons.

Fig. 10—A two-thermal element, fusible alloy-type relay.
In the relay, two thermal elements are associated with two heaters, which are connected in separate motor leads.



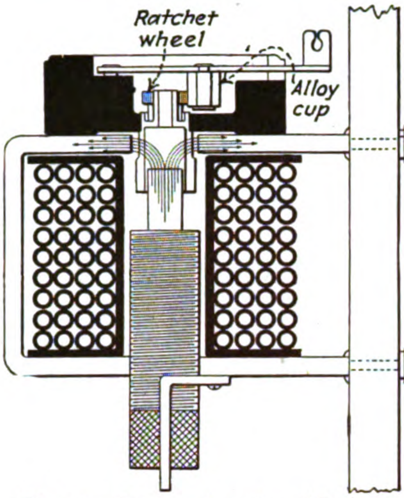


Fig. 11—Cross-section view of Inductotherm overload relay.
This alloy-type relay is essentially a transformer, the primary coil of which is in series with the motor lines. The alloy is contained in the small cup mounted in the top of the heater element. This alloy holds a ratchet wheel shown at top from turning when it is solid. An overload melts the alloy, permitting the ratchet wheel to turn and open the relay contacts.

Construction of Low Truck for Shop Use

IN MANY of the smaller shops there is no provision for moving heavy loads, such as machines and large and cumbersome boxes, by any means other than rollers.

The low truck described was devised by the writer, and has not only filled, but has exceeded all expectations for the above purpose.

The construction consists of two parallel frame pieces connected by a number of 1-in. cross-pieces and resting on four sets of casters. The cross-pieces are of oak and are screwed to the frame. The casters are of the double-wheel type, so that each truck rests on eight wheels. Several of these trucks were made so that machines set up on legs could be moved. Advantage can be taken of the lesser width occupied by placing four trucks parallel to the length of the machine rather than using but two trucks crosswise, that is, one at each end.

Jena, Germany. HENRY SIMON.

Subscription Swindler Gets 18 Months in Jail

THROUGH the efforts of the National Publishers Association, in co-operation with Mr. John Schaefer, Manager of the Trade Periodical Service Company, New York, a national subscription agency specializing in trade and technical papers, the fraudulent agent, "Peter Le Gaire," alias "Paul Leland," was tried recently in Philadelphia, found guilty by a jury of the Court of Quarter Sessions, and sentenced by Judge Samuel L. Reed to eighteen months in the county jail.

This agent was well known to many publishers of trade periodicals, as his dishonest practices were confined mostly to that field. His record shows that he began fraudulent solicitation of subscriptions in 1924, and during the latter part of that year, and in all of 1925, he operated in Southern, Eastern and Middle Western states, appropriating the name of the Trade Periodical Service Company, 1400 Broadway, New York.

During 1926 and 1927 he used the name of the Trade Journal Circulation Company, 269 Broadway, New York, using printed receipts with that name and address, although there is no such firm in New York City.

To protect the readers of McGraw-Hill publications against the operations of fraudulent agents, each subscription agent of this company is required to carry an identification slip similar to that shown in the accompanying illustration. The company seal is put across the photograph, so that there can be no chance of substitution. Subscribers are cautioned, therefore, in dealing with solicitors.

Fac-simile of identification slip carried by authorized McGraw-Hill subscription agents.

McGraw-Hill Publishing Company, Inc.
Tenth Avenue at 36th Street
New York, N. Y.

This is to certify that
Mr. ... Cateman
whose photograph and signature are hereto affixed is authorized to solicit and collect on all publications of the McGraw-Hill Publishing Company, Inc. to wit:

This photograph not valid unless cut by company seal

Power	Chemical and Metallurgical Engineering	Coal Age
Electrical World	Engineering and Mining Journal	Industrial Engineer
Electrical West	Bus Transportation	American Machinist
Electrical Merchandising	Radio Retailing	Ingenieria Internacional
Electric Railway Journal	Construction Methods	Engineering News-Record

This authorization is similar to that issued to all our field subscription men and expires December 31, 1927. It must be renewed at that time.

Director of Circulation Manager Field Sales

INDUSTRIAL ENGINEERING

Application and Operation of Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

Published by McGraw-Hill Publishing Company, Inc.

G. A. VAN BRUNT, *Editor*

New York, November, 1927

Capitalizing the Service to Production

IN THE old "easy" days of pre-war American industry, most of the effort toward improvements centered about the production functions. In fact a great many plant managers made a broad division, in accounts, between productive and non-productive labor. If the ratio of non-productive to productive labor was high, it was taken as evidence of bad management. Hence the pressure was in general toward reducing the non-productive items.

Strangely enough, it developed that there was no relationship between a low non-productive labor ratio and a good profit showing. On the contrary, many of the plants which made the largest profits had a high ratio of so called non-productive labor.

Out of this anomalous situation came the truth as we know it today. There is no such thing as non-productive labor. All labor is productive. The man who cleans the shop windows may increase the producing efficiency of the department ten per cent, through providing the operators with better light. His contribution to manufacturing profits may easily be greater than that of the mechanical genius who doubles the rate of output of a single machine. The influence of these so called non-productive jobs are tremendous, but it works two ways. The oiler who is responsible for lubricating a few bearings may, through neglect, shut down an entire manufacturing department for several hours, and cause more actual loss of production than if four or five operators were to spoil their week's work.

In addition to this there is another important angle to the cost saving possibilities on the Services to Production. This phase of plant operation often offers a rich field for cost savings through waste elimination. Having been less closely scrutinized by management than has production there are more undisclosed wastes. One can arrive at the efficiency of an individual production machine much more readily than at the inefficiency of the plant's power transmission or its handling methods. Losses in these services, which are part of the factory "overhead," are concealed and hard to get at. That is all the more reason for taking pains to unearth them. After the surface gold has been picked up the miner must dig deeper for his treasure.

Progressive plant managers today rank the importance of these and the many other non-productive functions which comprise the Services to Production on a par in importance with Production itself. They know that good or poor power transmission, handling methods, lubrication and maintenance may easily mean the difference between a manufacturing profit or a loss in a year's operations.

Radio—A New Tool for the Maintenance Department

IN ADDITION to its wide popularity as a fireside entertainer, and a medium for the transmission of news, radio bids fair to win recognition as a valuable aid in the inspection of electrical equipment. Radio receiving sets are being used by central station engineers to check up the condition of transmission lines. Such sets have also been employed by radio dealers and others to locate sources of interference with satisfactory radio reception in homes. Recent developments would seem to indicate that in a set having the proper characteristics, the maintenance department of industrial plants will have an extremely useful tool.

A few days ago an engineer discovered by the use of a portable receiving set that a medium-sized direct current motor driving a fan was not operating properly. Subsequent investigation showed that one of the commutator bars was low.

In another case, a manufacturer of radio sets discovered a number of cases of incipient trouble with motors, while seeking to clear up interference that was annoying when new sets were being tested.

In both of these instances a simple regenerative-circuit set of rather low sensitivity was employed. The defective motors were located easily, and without the necessity of getting close to them.

Much work will doubtless be required to determine the possibilities and limitations of this new tool, but the advantages which it offers warrant careful study. The editors will be glad to learn the results obtained by any readers who have used receiving sets for checking up the condition of electrical equipment.

Clean Bearings Seldom Are Out of Repair

A COATING of grease and dust on a bearing may be the direct cause of a fire. A clean, iron surface on a bearing dissipates heat with sufficient rapidity so that the ignition point is seldom reached. Grease, oil or dust over the bearing speeds up ignition, often to the point of a flash fire or, depending on the nature of the material, an explosion.

"The very effort necessary to cleanliness creates a higher morale. Pride on the part of the owners and managers carries down through the ranks. Clean bearings seldom are out of repair. The pride that induced cleanliness insures a smooth

running bearing, while the bearing that is buried in grease and dirt runs until it is too hot to continue."

Industrial operating men may well ponder over the above statement of Eugene Arms, Manager, Mutual Fire Prevention Bureau, Chicago, Ill., at the recent National Safety Congress, while discussing the relation of good housekeeping to fire prevention. The elimination of a fire hazard, however, is not the only reason for keeping clean the power transmission equipment.

Dirty bearings (excepting, of course, those in the industries in which dust abounds, such as cement manufacture and a few others) usually indicate neglect, and neglect generally spells trouble. If the bearing is inspected and serviced regularly and properly and the oiler has the right attitude toward his work, the accumulation of dust or lint is removed so that it cannot enter the bearing when servicing. Even anti-friction bearings lubricated by the pressure gun system should be wiped off to prevent dirt which has settled on the grease or oil fitting from being forced into the bearing.

Some serious fires have resulted from neglected and dirty bearings; however, the monetary value of the lost time and interference with production from this same cause probably exceeds the loss from fire. Thus the necessity of keeping bearings clean applies to every type of plant, even though the dusts are not combustible. Also, "a good oiler is known by the bearings he keeps in service."

How Many of Your Belts Are Overloaded?

PROBABLY 90 per cent of all trouble with belts is caused by overloading. This opinion was recently expressed by an engineer who has had many years of experience in designing industrial power drives. In explanation of this statement, he pointed out that much still remains to be learned about the transmission of power by belts. Thus sheer ignorance leads to many errors in calculating the size of belt required for a given application.

Again, differences in the quality of the leather, and variations in the tanning process and subsequent treatment, make a great deal of difference in the power-transmitting capacity of belts. This is one of the reasons why one belt may be able to pull a given load with a fair margin of safety, whereas another belt of the same width and thickness and to a casual glance apparently identical in every way, will fail long before the other one, under the same load.

It is unfortunate, not to say inexcusable, that responsibility for overloaded belts frequently rests with the designers of machines, who provide their equipment with pulleys that are too narrow, or too small in diameter, or both. When the design of the equipment is such that larger or wider pulleys can not be used there is nothing to do but make the best of a bad situation, and accept belt trouble and short life as inevitable, unless some other type of drive can be employed.

Failure to realize that putting new machines on a lineshaft, increasing speeds, and otherwise changing operating conditions may seriously overload the belt drives, is another prolific source of trouble.

A belt of good quality, when properly loaded and cared for, will give a good many years of trouble-free operation. Whenever a belt does not perform in this manner, it is the part of wisdom to determine whether that belt is being loaded beyond its capacity.

Study Effect of Rearranging Equipment On Power Drive Layouts

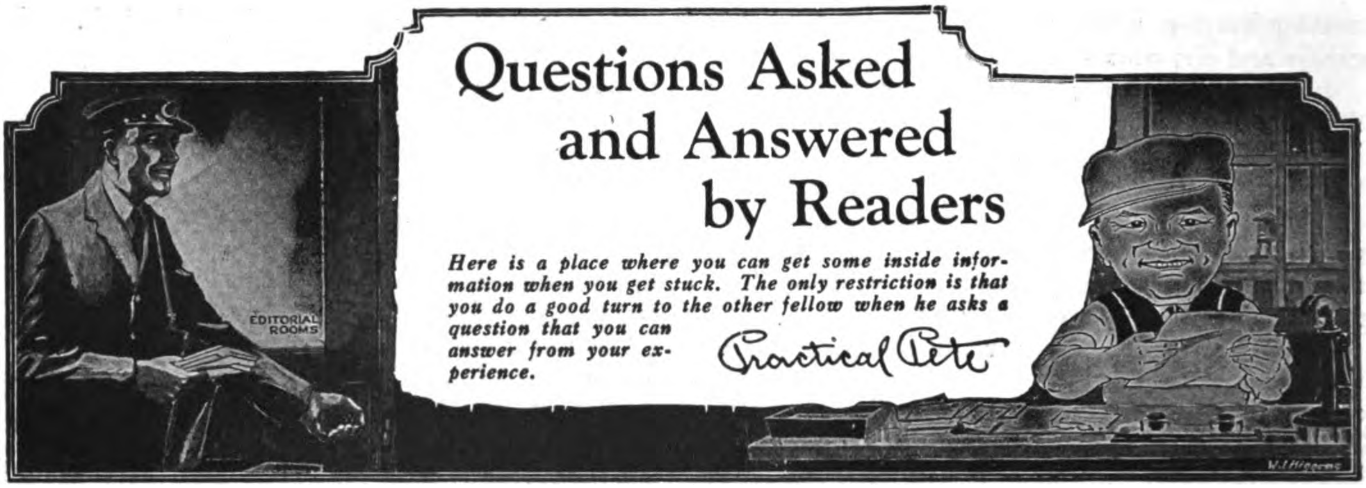
INCREASED production schedules frequently make it necessary to rearrange production machines, or add new units. From the production standpoint such changes may be simple and easily accomplished, but they often present power drive problems that need careful attention.

Any rearrangement of machines should be preceded by a close study of its effect on the existing methods of driving them, unless individual drive is used throughout. In this case overloading of feeders is one of the main points that requires checking. However, when machines are driven in either large or small groups from lineshafts, the question of overloading, or making existing equipment fit the new conditions becomes of prime importance. Even so simple a procedure as speeding up a lineshaft should not be regarded as of no consequence. An increase in speed or the addition of one new machine may overload a belt drive sufficiently to cause no end of trouble.

Again, decreasing the center distance between shafts may, by reducing the arc of contact on the small pulley, lead to excessive belt slippage and wear.

Oftentimes the troublesome and expensive drives that can be found in almost any plant can be traced to changes that were hurriedly made to meet production demands. The wishes or needs of the production department must, of course, be given careful consideration, but that is not sufficient excuse for installing makeshift drive arrangements, or attempting to lay out a satisfactory drive under impossible conditions.

An emergency may justify the use of makeshifts, but there is no hope of obtaining trouble-free service from power drives or other equipment that is installed or operated without regard to good practice.



QUESTIONS

Who Can Answer These?

Adjusting Double-Reduction Chain Drive

I have three shafts connected by two silent chains which must operate with fixed center distances between the shafts. This does not permit shifting the shafts for adjustment of the distances between them to compensate for wear or stretch. The drive will operate satisfactorily with a new chain for a year or two but after that it causes considerable trouble. Could any reader offer any suggestions on overcoming my difficulty with this drive.

Chicago, Ill. N. H. N.

Difficulty With Arc Welding Rods

Frequent trouble with one or more of our arc welding machines, which operate from 10 to 15 hr. per day, is due to the weld rods suddenly becoming red hot from tip to handle. The result is that instead of the molten metal on the end of the rod adhering to the weld, it only drops off to lay on the surface. Although we have found out that a machine giving trouble will run properly after a 5-min. shutdown, several tests failed to reveal the cause of the trouble. We shall appreciate readers telling us the reason and remedy of our difficulty.

Harvey, Ill. H. J. B.

Transformer Core Inspection

In order to make room for some new equipment we wish to move some of our transformers. The proposed location for them will cause some inconvenience whenever the transformer cores are removed. So we are interested in learning from readers how often the cores should be removed. Also, what methods are used in inspecting and cleaning the cores?

New Orleans, La. F. H.

Determination of Power Factor for Synchronous Motor

We have a 170-hp., 220-volt unity power factor, synchronous motor that operates at 50 per cent of its rated load. When the maximum excitation current of 8.1 amp. is employed from its direct-connected exciter, a leading power factor of 70 to 80 per cent is obtained at the motor, and at unity power factor the excitation current is 5 amp. As the plant power factor is 86 per cent when this motor is not operating, I shall be pleased to have readers explain the method of determining the proper power factor at which to operate this motor.

Chicago, Ill. H. F.

Voltage Regulation of Three-Phase System

Assume equal spacing between all three lines of a three-phase line having two induction-voltage regulators of 10 per cent rated regulation at the receiving end. If a balanced load is increased indefinitely, will each phase continue to receive the same amount of automatic regulation; that is, hold the same regulated voltage until both regulators reach the maximum boosting position? If not, how much regulation per phase can be given by this connection of regulators with indefinitely increasing balanced load? The connection of regulators referred to is this: In a three-phase line, ABC, regulator No. 1 is connected with its series coil in line A, and the potential terminals connected across phase AB; so that if a test were made with the regulator rotor in a boosting position and line C entirely removed from source to the load during this test, phase AB voltage would be boosted. No. 2 regulator is connected with its series coil in line C, and the potential terminals connected across phase BC; so that a test made with the regulator rotor in a boosting position and line A entirely removed from the source to load during the test would show the voltage of phase BC to be boosted. We shall appreciate readers giving vector diagrams to illustrate the points in question. Also, is the two voltage-regulator system of regulation in three-phase circuits considered superior to three single-phase regulators electrically as well as economically.

Beardstown, Ill. F. H. L.

Size of Leads for Secondary of Instrument Transformer

On our incoming lines we have an inclosed, tank-type metering outfit which contains 200 volt-amp. instrument transformers serving a G. E. DS-6, polyphase wattmeter. We have had so much trouble from fluctuating power that we want to obtain a graphic record of the load and voltage, but it will be necessary to install the meters 2,700 ft. from the metering tank. Will readers tell me if this can be done without affecting the registration of the watt-hour meter, and what size secondary circuit will be required to compensate for the drop, so that true registration will be obtained with the graphic meters?

Worcester, Mass. D. E. M.

ANSWERS

Received to Questions Asked

What Determines Minimum Thickness of Brushes?

I recently tried to eliminate sparking on a d.c. compound-wound generator by reducing the thickness of the brushes from $\frac{3}{8}$ in. to $\frac{1}{4}$ in. This reduced the sparking, but the commutator became so hot that it turned blue. Will readers please tell me (1) what limits the minimum thickness of brushes for d.c. motors or generators, and (2) how can I overcome this heating without using a thick brush which will again cause sparking?

New Haven, Conn. J. R. S.

ANSWERING the question by J. R. S., if the machine in question is of an old type—that is, made before 1910—it is more than likely that it has no interpoles, and if it gave satisfaction prior to the investigation and experiments by J. R. S., the trouble probably lies either in the brush spacing or setting, the quality of brushes, the field or the armature section. However, if the machine has always given a certain amount of sparking trouble, it may not be possible to eliminate the sparking entirely, because of faulty design.

One of the best things to do in a case like this is to ascertain if the brushes are secured in their neutral position. This is important and should be given careful attention, because the moving of some brush holders only a fraction of an inch out of the neutral position will cause sparking of the brushes.

One way of testing the neutral position is to operate the machine under load and then move the brushes until a minimum amount of sparking results.

On commutating-pole machines the electrical neutral should be accurately located and a voltmeter should be employed to determine the running position of the brush holder. When making such a test the voltmeter terminals should be connected on either side of one main pole. During the test the brushes are raised and the armature remains stationary.

After the shunt field is excited to about one-half the normal voltage, the circuit should be quickly broken. As the transformer action induces a current when the field circuit is opened, a voltage will be indicated on the meter, preferably a 5-volt meter, either in a plus or minus direction according to the side of main pole centers these connections are made. By moving the voltmeter terminals a point will be found where no voltage will be indicated when the field circuit is broken. The brushes should now be set at the neutral point thus determined.

If a thinner brush is employed, it will, of course, be necessary to use a brush with a lower resistance. In J. R. S.'s case I believe that the narrow brushes have not sufficient capacity and consequently overheat.

Although excessive brush tension will also cause them to heat, on non-commutating pole machines brushes of a higher resistance are generally necessary. Usually on non-commutating machines the brush contact resistance is from 0.3 to 1 volt, but, of course, when the brush heats up, the contact resistance is lessened. In this case more current flows when passing from one segment to another and the brush has a greater tendency to heat. A brush current density of about 35 amp. per sq.in. should be the maximum amount of current allowed to flow through them and a brush tension of from 2 to 3 lb. should be sufficient. GRADY H. EMERSON.

Birmingham, Ala.

Charging Storage Batteries From Exciter

In our plant we have a combination signal and fire alarm system operated from three 6-volt, lead batteries connected in series. Instead of sending them out every month, I want to charge them from the 125-volt exciter on our generator, which is in continuous service. In order to lower the voltage for charging I want to use a number of spare cast-iron grids that are kept on hand for a 50-hp. motor. Will readers, therefore, suggest a method of determining the resistance per grid, so that I can determine how many to use? R. C. B.

Grenada, Miss.

REPLYING to the question by R.C.B., the value of the fixed resistance may be determined in a general way as follows:

Obtain from the battery manufacturer complete details regarding the battery: that is, what should the normal, continuous charging rate be, or the trickle charge rate be, if these batteries are not to be used continuously for any extended period of time.

Since the maximum voltage of a 6-volt battery will not exceed 7.5, it will be necessary to provide a minimum resistance to take care of 125 — 7.5 = 117.5 volts at the ampere rate given to the battery; so 117.5 divided by this rate will give the minimum resistance in ohms to be used.

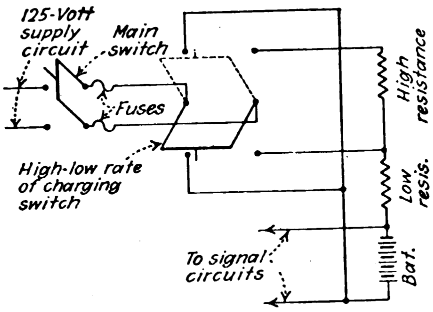


Fig. 1—This arrangement of two resistors allows a high or a low rate of charge.

At the trickle charge rate, the battery potential will be practically 6-volts; the resistance in circuit will then be required to take care of 125 — 6 = 119 volts.

Assume, for example, when the resistors are connected as shown in Fig. 1, that the maximum charging rate will be 5 amp. Then a resistance of 117.5 ÷ 5 = 23.5 ohms will be required, and if the trickle charge was 0.5 amp., a total resistance of 119 ÷ 0.5 = 238 ohms will be needed. It is clear, of course, that the added resistance for the trickle charge rate of 238 — 23.5 = 214.5 ohms would have only a continuous capacity of 0.5 amp., and, therefore, could be made up of a resistor of the tubular type. It is necessary, usually, to arrange the charging circuit so that the sections of resistance may be switched in as required.

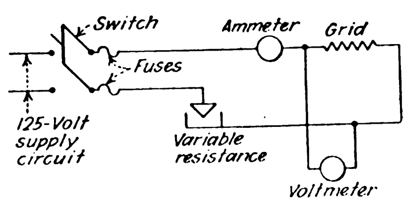


Fig. 2—How to connect a grid to find its resistance.

The resistance per grid could be determined by connecting a lamp bank or water resistance in series with the grid or group of grids, as indicated in Fig. 2, and also inserting an ammeter in the circuit. When the current is flowing measure the voltage across the grid or grids. The resistance may then be calculated from the formula R = E ÷ I; when R = resistance in ohms, E = volts, and I = amperes.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering & Management Corporation,
New York, N. Y.

ANSWERING the question by R.C.B., perhaps the simplest way of determining the resistance of the cast grids, which R.C.B. wishes to use as charging resistors, is that commonly known as the drop of potential method.

With this method a grid or number of grids may be connected in series, and a current passed through them, either from the exciter or from the batteries supplying the signal circuits.

While this current is flowing, the voltage across the grid or grids is measured with a voltmeter and at the same time an ammeter reading should be taken. From the simultaneous voltage and current readings, the resistance may be determined from the formula, resistance = voltage ÷ amperes. V. E. JOHNSON.

Milwaukee, Wis.

REPLYING to the question by R.C.B., the resistance of the grids can be measured by connecting several grids in series with the 18-volt battery, adjusting the number of grids used until about 10 amp. is flowing through the grids. Then to obtain the resistance of the grids in ohms divide the voltage drop across the grids by 10 amp. The resistance per grid may now be determined by dividing the number of ohms thus found by the number of grids used. It is probable that R.C.B. will find the grids too heavy for the purpose he has in hand. If so, I would suggest the use of one of three other methods.

A serviceable resistance for the work can be made by coiling about 20 ft. of No. 20 Nichrome or Chromel A wire connected in series with a charging circuit and wound on an insulator.

If a 1,000-watt radiant heater is connected in series with the charging current, it would allow just about the proper amount of current to flow from the 125-volt line to the batteries.

As a means of charging the batteries continuously, even when being used, one 125-volt, 8-cp. lamp may be connected in each of the two lines leading from the exciter; in this way the voltage between the signal wiring and ground is reduced.

J. F. MORGAN.

Chief Engineer,
Mercury Mills Ltd.,
Hamilton, Ont., Can.

IN ANSWER to the question by R.C.B., although the resistance of a grid may be determined in several ways, I will mention only two ways.

If a voltmeter and an ammeter are available, the resistance of a grid or a group of grids may be determined by noting the voltage drop around the grid or grids and the amount of current flowing. The resistance can then be calculated from the formula, R = E ÷ I, when R equals resistance in ohms, E equals voltage and I equals current.

In case an ammeter is not available, but a voltmeter is, then the resistance of a grid may be determined by connecting it in series with a known resistance. When the current is flowing, determine the voltage drop around the known resistance. Then the amount of current flowing can be determined from the formula I = E ÷ R. Next determine the voltage drop around the grid. The resistance of the grid may be determined by dividing this voltage by the current flowing in the circuit, as determined

by employing the known resistance.

As a means of varying the charging current, taps may be connected between the grids. These leads may then be connected to a short-circuiting switch or switches.

If the charging current should be interrupted at any time, current would flow from the batteries. So to prevent this some device should be installed to open the charging circuit whenever the charging current fails.

Lansdale, Pa. HORACE TURVILLE.

IN ANSWER to the question by R.C.B., I would suggest, as a convenient method, the use of a bank of lamps instead of the spare grids. With a bank of 120 to 125-volt, 32-cp., carbon lamps, a maximum of 10 amp. for the charging current is available. By this method it is possible to apply a charging current of from 1 to 10 amp., without the use of an ammeter, by simply screwing in the desired number of lamps. E. J. ELVISH.

Kaminstiquia Power Co.,
Fort William, Ont., Can.

Repulsion-Induction Motors Fail to Start

Several new $\frac{1}{4}$- and $\frac{1}{2}$-hp., 110/220-volt, single-phase, repulsion-induction motors operated satisfactorily for a few months, but now they either fail to attain full speed or refuse to start even under no load. Sometimes when the armature is turned over so that the brushes touch a different bar, the motor will start. The commutators are not rough or badly blackened, and tests indicate that the motors are in good condition. A receiver test, made when the short-circuiting device is removed, indicates that there are no open circuits in the armatures. Dead spots on the commutator do show up, but when it is turned over a few bars, these dead spots give a good test and the parts which previously indicated a good test give a poor one. Operating these motors under ideal voltage conditions does not help to cure the trouble. Will readers please suggest the cause and remedy for the trouble with these motors?
Quebec, Can. W. S. B.

REPLYING to the question by W.S.B., the voltage at the motor should be checked because the power of an a.c. motor varies as the square of the voltage, and occasionally low voltage causes trouble. Usually these motors are designed to operate satisfactorily if the voltage does not vary over 10 per cent. Transformers with poor regulation sometimes cause trouble with this type of motor.

The motor should be checked carefully for poor contacts and loose connections, and the governor mechanism should be examined and tested to see whether it functions at the proper time. Occasionally the governor mechanism needs to be adjusted to suit the load. Worn bearings, which cause a roaring sound when the motor is started, will cause trouble, although the rotor may not be rubbing on the stator.

The brush setting may need adjusting. This can be done while the motor is running by loosening the setscrew and then moving the brushes until the correct position is found. After the brushes have been set, their position should be marked. With fractional horsepower repulsion-induction motors special care should be taken to make certain that the brushes are making good electrical contact with the commutator bars.

If the motor still continues to give trouble, the windings must be tested, and several tests should be made: namely, for grounds between wires and frame, and for open circuits, and shorts between wires.

GRADY H. EMERSON.

Birmingham, Ala.

Interpretation of Graphic Meter Record

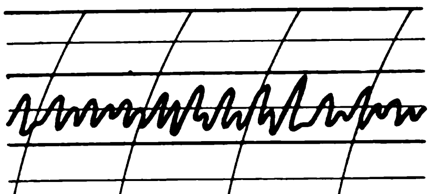
I have run several tests on a gear-driven duplex plunger pump and should like to know why the graphic wattmeter records are as shown below instead of being a straight line, thus indicating a steady power input. The cranks on opposite

sides of the gear are set at 90 deg. Wi.l readers please tell me whether such a chart is normal, or is due to defects in the meter, or in the pump or motor. Also, can grapic meter records be used to detect or locate pump troubles?
Detroit, Mich. S. B.

IN ANSWER to the question by S. B., the chart indicates to me that there is some obstruction in one valve or passage at one end of one cylinder. The high points in the chart accompanying the question are probably due to the extra power needed to force the water past the obstruction. Although there may be a faulty valve in one of the cylinders, I doubt it.

The accompanying illustration shows a section of a chart taken by a wattmeter connected to a motor-driven, three-cylinder, single-acting plunger pump. Before investigating the performance of this pump we decided, after examining the chart and the action of the pump, that the suction valve on one cylinder did not feed properly, thus causing the irregularity in the cycles indicated by the curves on the chart.

When charts are taken of rotary and centrifugal pumps, the curve should be approximately flat. Trouble in pumps of this type is more difficult to detect than in reciprocating ones. It is possible, however, for an experienced man, when furnished with the characteristics of the pump, to determine approximately when a centrifugal pump is discharging its usual amount of water.



Variations in the power consumption of a three-cylinder, single-acting plunger pump.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

REPLYING to the question by S. B., the graphic meter record curve is a good one for certain types of duplex pumps. In fact, any type of piston pump or compressor when in good condition should make a curve as good as the one shown with the question.

It will be noticed from the curve on the meter that on the intake or suction stroke the power consumed is small but increases at the beginning of the discharge or compression stroke until the piston has reached the end of the stroke.

If either the suction or discharge valves were intermittently sticking open, the curves would be irregular, or if one cylinder were doing more work than the other, every other curve would be different, in which case the pump would not work evenly. With a centrifugal or rotary pump, however, a curve that is nearly flat or straight should be obtained whenever the load is approximately constant.

Los Angeles, Calif. J. W. BANTAU.

Emergency Lighting from Current Transformer

We have a 440-volt motor in service at a considerable distance from the 110-volt lighting system. In the one phase of the motor circuit there is a 20:5-amp. current transformer for operating overload trips. Inasmuch as we do not want to extend the lighting system for only one lamp, and do not wish to install four lamps in series, will readers tell me whether I can cut a lamp in the secondary circuit of the current transformer? If so, what size and type of lamp should be used? A. K. R.
Superior, Wis.

IN REPLY to the question by A.K.R., the questioner is cautioned against attempting to accomplish the result desired without due consideration of the factors involved.

The voltage on the secondary side of a current transformer varies in value, depending on the motor load. Therefore, even for a fixed load, the voltage may be very low, although, for instance, a 20:5 ratio transformer were operated at a 10-amp. load. Since the normal rating of such a transformer is about 50 va., the voltage would be, neglecting other factors, not more than 10 volts maximum at full load, and this, of course, would vary with fluctuating loads.

If the lamp was connected directly across the secondary of the transformer, in multiple with some other device, it would interfere with the operation of that device; if connected in series, there would be the danger of the lamp open-circuiting and thereby on account of the high voltage induced at the secondary

terminals, possibly causing damage to the current transformer.

It might be possible to get a special low resistance lamp to give a more or less satisfactory result, but in any event the result obtained would be a poor one.

If the expense of installing a 440:110 potential transformer is too great, a comparatively cheap way of accomplishing the desired result would be to connect a 110-volt lamp in series with a tubular resistance across the 440-volt leads. This construction would require two sockets and a resistor that could be screwed into one of the sockets; the circuit to be arranged so that the resistor was in series with the lamp. The Ward Leonard Co., as well as other manufacturers, could furnish such a type of resistor at a small expense.

It would even be better to install four 110-volt lamps in series rather than attempt, in any way, to make use of a current transformer's secondary circuit for such a purpose.

C. Otto von Dannenberg.

Electrical Division,
General Engineering & Management Corporation,
New York, N. Y.

Replying to the question by A.K.R., do not attempt to install a light in the secondary circuit of a current transformer. To do this will prevent the protective apparatus connected in the secondary circuit from functioning properly. In addition to this disadvantage probably insufficient light will be obtained and in case the lamp burns out, the transformer will build up a voltage that may injure the transformer as well as the operator.

To furnish light for this installation it may be advisable to install a 440:110-volt transformer. A transformer suitable for this work, which is small, compact and air cooled, may be obtained at a reasonable cost from several manufacturers of electrical equipment.

Guy H. Wintersteen.

Cleveland, Ohio.

In reply to the question asked by A.K:R., it is not practical to install a lamp in the secondary circuit of a current transformer.

To place a lamp across the secondaries of this current transformer will, in reality, as far as the lamp is concerned, act about the same as though the lamp was cut in series with a line leading to the motor, except that the current available in the secondary of the current transformer is only one quarter of the motor current, as the ratio of the current transformer is 20:5. So, as the load on the motor varies, the current supplying the motor will vary, thus causing the current in the secondary of the transformer to vary. These changes will cause the current available for the light to vary anywhere from 0 to 5 amp. Also, when the motor is stopped it will not be possible to light the lamp, and when the motor is running, I doubt if the light from the lamp will give satisfaction.

Probably the most inexpensive method of furnishing light at the motor can be accomplished by connecting two 220-volt lamps in series across one phase of the power circuit.

A. C. Barker.

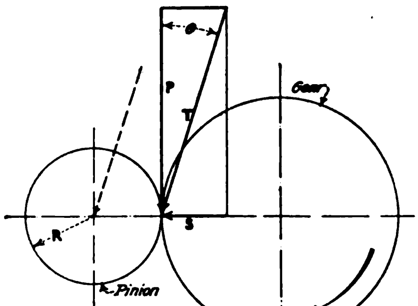
Chief Electrician,
W. S. Libbey Co.,
Lewiston, Me.

Location of Motor Pinion

Is there a preferred location of the motor pinion with respect to the driven gear? The accompanying diagram shows four different drive arrangements, one having the motor pinion on top of the driven gear, another with the pinion at the bottom, and others with the pinion on either side of the gear. The direction of rotation of the gear and pinion is indicated by the arrows. Which of these locations if preferred from the standpoint of stress on the motor frame and on the foundation bolts, lubrication of gear and pinion, and ease of maintenance and inspection? Are they all equally good? I should like to have some of our readers discuss this question, and give me the benefit of any experience they may have had with such a problem.

Landgraff, W. Va. U. J. S.

The accompanying force diagram shows the lines of application of the two forces of a pair of meshing spur gears. This, I believe, will help U. J. S. to get a better understanding of his gear drive problem.



Application of the forces or pressures of a pair of meshing spur gears.

The tangential force, P, is calculated from the formula: $P = (63{,}000 \times \text{hp.}) \div (\text{r.p.m.} \times R)$

Where hp. = horsepower of motor.
r.p.m. = revolutions per minute of motor.
R = pitch radius of motor pinion in inches.

The angle θ is equal to 14.5 deg. plus 3 deg. The tooth contact angle, also known as tooth pressure angle, is 14.5 deg. for involute cut teeth, which are most generally used. The friction angle is assumed to be 3 deg., which, with the 14.5 deg. added, equals 17.5 deg.

The force S, tending to spread the two gears, due to the tooth pressure angle, is equal to: $S = P \times \tan\theta$. The resultant pressure T can be found graphically or by calculating $T = \sqrt{P + S}$. The arrows indicate the direction of the force. The pressure T is that which acts on the bearing of the motor and in the direction as shown by the dotted line.

Motors, except the ball- and roller-bearing types, are generally equipped with ring-oiled sleeve bearings. Because of the nature of the design, ring-oiled bearings have the upper half cut to take the oil ring. This reduces the bearing surface to some extent, although it is taken into consideration in the design of the bearing; however, there is more bearing surface in the lower half and therefore the arrangement B, as given by U. J. S., would be more desirable. The lubrication conditions are improved in this arrangement, because the oil is fed over the shaft which wedges the oil between the shaft and bearing in the direction of rotation.

The stress on the motor bearing and frame is down 17.5 deg. from the vertical, which will aid in holding the motor in place. The drive shown in A of his diagram gives the reverse conditions just mentioned for position B. By turning the force diagram to suit arrangements C and D, it will be noted that the resultant pressure is toward the side of the motor, thus requiring the motor to be doweled in place. Split bearings are most likely used on the gear shaft, however, and the pressure would be toward the split or joint between the two bearing halves. Wear would start at this point and would be more rapid than if the pressure were directed toward the more solid upper or lower halves of the bearing. In practice all the arrangements shown are used with equally good results, although preference should be given to arrangement B, where possible, for easy maintenance, inspection, lubrication and good mounting.

E. H. Laabs.

Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

The gear arrangement shown at B in the diagram accompany U. J. S.'s question is to be preferred, because with this arrangement there is a downward thrust on the bearings of the shafts supporting the gears, whereas the arrangement in diagram A produces an upward thrust on the bearings and consequently increases the load on the holding bolts and the bearing caps.

From a lubrication standpoint the arrangement at B is also to be preferred when the gears are enclosed in a sheet metal or cast-iron gear case with its dividing line along the center line of the gears, thereby preventing leakage of oil. With this arrangement the rotation of the gears is such as to lift the oil a shorter distance to the mesh line than is the case with the arrangement shown at A.

Ordinarily it is much easier to inspect and maintain gears mounted horizontally than is the case when one gear is above the other, because covers can be removed without disturbing the bearings. Another difficulty encountered with the vertical arrangement is that when the bearings wear there is danger of throwing the gears off the mesh line, and if the upper bearing should wear more than the lower one, there would be a tendency to crowd the teeth together and cause faulty operation.

C. E. Schirmer.

Chief Engineer,
Toledo Crane Co.,
Bucyrus, Ohio.

Electrical Service

AROUND THE WORKS

How an Electric Heater Lowered Cost of Heating Water

ELECTRIC heat has been adopted for heating bath water on holidays or other days when most of the employees of the Valier Coal Co., Valier, Ill., are not working.

This addition to the existing heating system was found necessary because of the high cost of furnishing hot water to the maintenance and construction men, who frequently have to work outside of regular working hours.

Hot water during regular working hours is provided for 600 men from a steam-heated system. The operation of this system requires 5 tons of coal per day and the services of three firemen, thus entailing an expense of $34.25 per day.

As only about 15 maintenance and construction men are employed, it was deemed advisable to install an electric water heating unit, which is capable of providing hot water for 50 or more men. With this electric heating system the water reaches bath temperature in three minutes after the current is turned on.

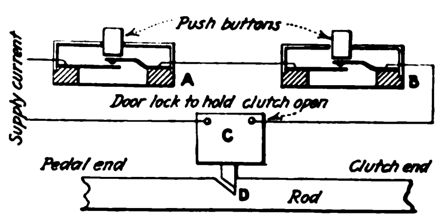
Some of the equipment to be provided with hot water consists of seven hot-and-cold showers. The water is heated in a 235-gal., heat-insulated, hot water tank by six 5,000-watt, 220-volt, helical sheath-wire immersion heating units furnished by the General Electric Co. Heating is governed by complete thermostatic control, and the installation is so arranged that it will not interfere with the heating of water by steam.

It has been found that the cost of electrically heating the water on idle days is about $7.65, which means, of course, a substantial saving over the steam system method of heating water at such times.

Installation of Safety Lock on Pedal-Operated Machine

SOME time ago I was asked to devise some sort of positive method for preventing operators of punch presses from getting their fingers caught under the dies. On these presses the operation of the die is controlled by a foot pedal. In one particular plant where I was engaged various mechanical devices had been tried out on the presses, but none of them proved satisfactory. So I built an electric device for releasing the foot pedal at the proper operating time of the machine.

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.



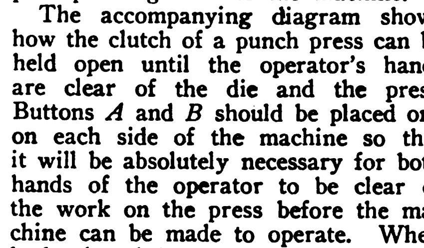
The clutch rod is held by the catch at D until the lock, C, has been released by pushing the two buttons, A and B.

The accompanying diagram shows how the clutch of a punch press can be held open until the operator's hands are clear of the die and the press. Buttons *A* and *B* should be placed one on each side of the machine so that it will be absolutely necessary for both hands of the operator to be clear of the work on the press before the machine can be made to operate. When both *A* and *B* are pushed, an electric circuit is completed through the door lock *C*. When the door lock is energized, the catch at *D* is released, thus allowing the rod, which engages the clutch, to be operated by the foot pedal.

CHAS. A. PETERSON.
Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Simple Method of Constructing Steel Guard Rail

SEVERAL months ago a truck backed off the ramp of our shipping room, smashing the fence and the side of a freight car. To prevent a reoccurrence of this incident, a guard rail was erected, as shown in the accompanying illustration.



It took two men approximately 4 hr. to install the posts, which were made of 4-in. x 3-in. x ½-in. angle iron. However, less than 30 min. were required to weld the rails to the posts. Two 3-in. x 2-in. x ⅜-in. angle irons were used for the rail because they happened to be stock material. We now have a very substantial guard rail.

A. F. DAVIS.
Vice-President,
The Lincoln Electric Co.,
Cleveland, Ohio

Generator Overload Relieved by Idle Exciter

A LEATHER plant was faced with the alternative of either increasing their generating capacity or else cutting down their lighting load. Their generator was a belt driven machine rated 140 amp. at 115 volts, and when the full lighting load was thrown on, the ammeter frequently indicated 175 amp. As a result numerous shutdowns were necessary from excessive heating and flashing at the brushes. In view of this overload, they had been advised to get a larger generator but the expenditure was not approved because the management argued that there had been no overload the previous Winter.

On my arrival, after I had been called in on this job, I found the generator so hot that I could not touch the commutator even though it had been shut down for some time. When looking for the cause of the flashing I found that the heat had been great enough to melt the solder out of one of the commutator risers, thus opening one side of the two parallel windings, and consequently throwing all the load on the other winding for an overload of 100 per cent.

After soldering this lead in again, I looked around for the cause of the overload and found that they had added an entirely new machine shop and offices during the summer, besides increasing their lighting load in the plant itself to some extent, which accounted for the fact that there had been no overload the previous winter. In the engine room, I was shown a 550-volt alternator with a belted exciter, which had not been used for over 5 yr. This fact was apparent from the dirty condition in which I found it. The exciter was rated 30 amp. at 125 volts, which was just about the right capacity to give relief to the main generator. It took me 3 hr. to clean that exciter for I had to dig the dirt out of the oil wells with a knife.

After a thorough clean-up, the small exciter was swung up in front of the main generator, which was driven from the main drive shaft in the engine room, and an extra pulley was placed on the driveshaft beside that of the main generator. The next problem was to connect the pair of generators so that each would take its share of the load. It was obvious that they could not be connected in parallel, for their characteristics were dissimilar; that is, one generated 115 volts, while the other generated 125 volts at full load. In addition, a total failure of the large generator would have thrown the full load onto the small one, probably with disastrous results.

Looking over the main distribution panel, I found three small switches, strap-connected to the main bus, whose total load as read by an ammeter was 30 amp. After disconnecting these straps from the bus, I connected them with a pair of No. 10 jumpers to the blades of a double-pole, double-throw knife switch and to the three switches mentioned.

I wired the small generator to one set of terminals of the switch, while to the other set of terminals I connected a pair of No. 10 jumpers to the 110-volt a.c. city mains, so that in case of trouble or a shutdown in the generator or shafting service would be uninterrupted by switching to the auxiliary city service. This solved their problem in a simple and economical manner. No trouble was experienced with the small generator for it excited itself at once, which speaks well for the machine, considering that it had lain idle and neglected for 5 yr. The ammeter on the large generator never goes beyond 140 amp. now, while the small machine runs along steadily at 30 amp.

No doubt one large generator would have been better in regard to operating conditions, in view of future expansion, but on the other hand, the cost of a new machine was saved by placing into operation a piece of equipment that was lying idle. The exciter will always be ready in this location, however, to be put back into service on the alternator if it is ever decided to use it again.

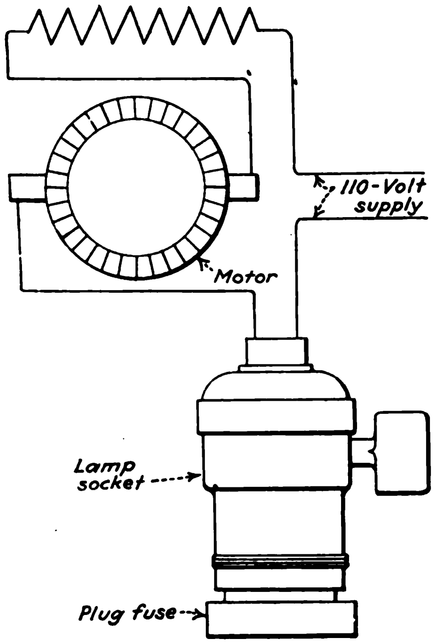
H. G. MILLICAN.

Miami Electric Service Co.,
Miami, Fla.

Application of Lamp Socket as Emergency Switch

IT WAS necessary not long ago to connect a number of small motors for immediate service in a manufacturing plant. As these motors could be started without a resistance or a control device, nearly any two-pole switch would be suitable for this service. However, no switches were available, and as we could not wait for them to be ordered, the plant electrician decided to use lamp sockets instead of the ordinary starting equipment.

At first each socket was shorted with a brass strip fastened under the tongue of the socket, but later the strip was replaced by a fuse plug of the proper size, as shown in the accompanying illustration.



How a lamp socket and plug fuse can be connected to control a 110-volt fractional horsepower motor.

In case of an overloaded or grounded motor, the plug fuse would blow and thus save the motor. After using various kinds of lamp sockets, it was found that a pull-chain socket shorted with a plug fuse made the most satisfactory emergency switch for this service.

C. V. HULL.

Charles City, Iowa.

Convenient Method of Keeping Charts and Log Sheets

TWO handy all-steel cabinets are used by our company for filing recording charts and log sheets. The smaller one is located near the switchboard and the larger one is in the file clerk's office.

In the cabinet near the switchboard, which is shown in the accompanying illustration, a supply of charts and log sheets is always available. The shelves in the upper half of the cabinet, where the charts are stored, are two compartments deep. Each shelf in the lower half has but one section and one compartment in order to accommodate the large log sheets.

Charts and log sheets are kept in a steel filing cabinet, arranged as shown here.

For the purpose of keeping all charts neat and uniform in appearance, they are handled by the operator on the afternoon shift. The names of the engineer and the instrument on which the chart was used are stamped on each chart, several rubber stamps being supplied for this purpose.

In the larger cabinet in the file clerk's office all of the current year's log sheets and charts are kept together with those of the preceding year. This method of filing makes possible a quick and easy comparison of past and present operating data.

E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Savings Effected by Changing Electric Light Fixtures

A NEW type of electric light fixture is being used throughout our plant because it is cheaper to operate and maintain than the old type. The old ceiling fixtures had a frosted glass reflector of the semi-indirect illumination type, which reflected approximately 40 per cent of the light against the ceiling. These old fixtures were installed in such a way that it was necessary for a man to climb up on steel girders and stand on an I-beam to pull a lamp fixture in where it could be cleaned and inspected. From 15 min. to ½ hr. was required to change a burned-out lamp and 40 min. or more was needed to clean the glass reflectors. This method of taking care of the lights was hazardous both for the repair man and for those who walked underneath the fixture while it was being cleaned.

Today all of the old fixtures have been replaced by Thompson safety switch lamps with an Ivanhoe, R.L.M., 18-in. reflector, which is designed to throw all the light downward.

Instead of 750-watt lamps, 500-watt lamps are being used. As about five lamps per fixture per year are used and as the cost of each lamp is $2 less than the 750-watt lamp there is a yearly saving of $10 per fixture. The reduction in size of each lamp, 250 watts, also makes a saving in current. As each lamp is operated on an average of 11 hr. a day, there is a saving of 1,004 kw.-hr. per year per lamp, at a cost of 1.5 cents per kilowatt-hour. This represents a saving of $15.05 in cost of current. Therefore, the savings per fixture per year amount to $25.05.

Now that it is no longer necessary to climb up on the I-beams for repairs or to replace lamps, because the fixtures can be lowered to the floor, considerable saving in labor may also be credited to the new fixtures. The net cost of installing the new fixtures was $31.10 per lamp. By comparing this figure with the saving credited to the new installation it is evident that the saving in a year nearly pays for the cost of the new fixtures.

E. J. ELVISH.

Maintenance Inspector,
Kaministiqua Power Co.,
Fort William, Ont., Can.

MECHANICAL MAINTENANCE OF *Power Drives*

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Roller Chain Used on Quarter-Turn Drive

UNUSUAL operating conditions sometimes make it necessary to devise unusual drives. An interesting example of this kind may be found in the plant of the I. H. Dexter Co. of Goshen, N. Y.

This concern manufactures flexible shaft couplings consisting of tooth flanged members joined by roller chain of sufficient width to cover, between the side plates, the teeth cut in the periphery of both flanges.

The flanges on the large couplings are faced in a gap-lathe which was assembled in the shop. Because this machine is used but part of the time, nicety of design was sacrificed to utility and the lathe stands, rugged but inexpensive, a good tool for the purpose.

It is used as a facing lathe only and is fitted with a special cross slide. The power feed is unusual and presents some features of interest. The feed screw runs the full length of the table and has the usual ball crank for hand setting. Power is applied to this outer end from above.

A countershaft runs directly above and at right angles to the end of the screw and the extended cross slide, and advantage was taken of this fact to join the shafts by a chain drive. This is unique in that it connects the shafts at right angles which makes it a quarter-turn chain drive. Roller chain is used and is practicable because of the long centers and the slight flexibility in each link of the chain.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Manufacturing Co.,
Middletown, N. Y.

Construction of Scraper for Cleaning Oil and Dust from Shafts

ACCUMULATIONS of dust and grease often make it necessary to scrape lineshafts from time to time in certain types of plants. A novel scraper for this purpose is shown in the accompanying drawing. This scraper is so made that it can be adjusted to suit shafts of various diameters. The eight scraping edges can be used a long time between sharpenings. The edge in use lines up square and lies flat on the shaft even though the handle is held out of vertical.

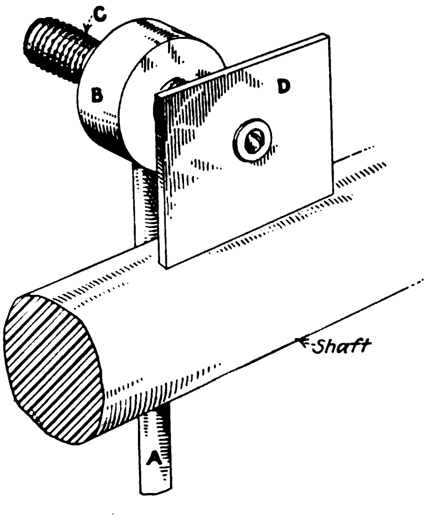
The handle *A* is of a length which enables it to be held from the floor. The handle is threaded at one end to fit into the collar *B* which is tapped in the center to take the scraper-holding-screw *C*. The scraper *D* is held in place by a screw and washer in the end of *C*. To operate this device the screw *C* is turned in or out of the collar *B* until the scraper *D* extends just past the center of the shaft to be cleaned, as shown. The operator stands on the off side of the shaft so that the rotation of the shaft is toward the scraping edge and pulls down slightly on the handle as he walks along the length of the shaft. If it would be objectionable for the scrapings to fall on the floor or machinery a basket arrangement could be placed on the handle *A* to catch the scrapings as they fall.

Although the scraper is hardened it does not cut into the shaft while cleaning it. However, merely scraping off the dirt soon tends to round the edge and the value of the eight scraping edges will be apparent. It is only necessary to remove the small screw and washer which holds the scraper *D* and turn the scraper over to get the second four edges. The edges are ground flat, as on a wood scraper, and a pull on the handle *A* brings the blade parallel and flat on the moving shaft.

Hamilton, Ontario, Can. H. MOORE.

Easily constructed device for scraping moving shafts.

Where accumulations of dust and oil on a shaft are undesirable, a scraper, such as this, handled from the floor, will quickly clean the moving shaft without danger to the operator. The scraper is adjustable to shafts of different diameters by turning *C* in or out of the collar *B*. The scraper can be set to the proper shaft diameter by measurement before placing on the shaft.



Precautions to Take When Using White Metal for Rebabbitting Bearings

THE rebabbitting and fitting of white metal bearings is one type of work which is largely dependent on the mechanic's skill and even the best mechanics fail occasionally. One of the principal pitfalls in this work lies in the delicate and unstable chemical composition of the white metal itself. If the metal is not carefully treated in heating and pouring, although the bearing may be poured successfully, the resultant bearing surface may not have the wearing qualities expected.

White metal is not the same as other bearing alloys, as the terms are generally understood. If the surface of the white metal is examined under a microscope, a number of hard crystals are shown immersed in a plastic material, much in the same manner as hard stones are immersed in a plastic tar compound in some of the road building materials. When installed in a bearing the journal presses on the bearing surface and the load is carried on the hard crystals; however, the plastic material yields and allows the load to be distributed evenly over the whole surface. This, at least, is what should happen in practice but, unfortunately, a good texture of metal is difficult to form and easy to damage.

Every white metal alloy has a critical temperature and, if it be heated much above this point, oxidation of the metals occur; this may lead to the inclusion of undesirable oxides in the poured metal itself. Metal oxides are hard, tin oxide approaches the hardness of hardened steel; if this oxide is on the bearing surface the result will be increased friction and overheating and it is also possible to slightly score the shaft. If the metal has been overheated a careful stirring as it cools down will remove, at least partially, the ill effects.

Molten white metal should always be kept well stirred; otherwise, its va-

rious constituents will not be uniformly distributed throughout its whole mass. The rate at which the bearing is cooled off after pouring is important; too rapid cooling results in a partial or complete prevention of the separation of the hard particles. These compounds remain partly dissolved and even if and when they do segregate, their size remains small. Too slow or retarded cooling causes excessive growth of the harder constituents and a general coarsening of the microstructure; this embrittles the surface.

The rapidity of the cooling process is partly dependent on the pouring temperature, the temperature of the shell and mandrel, and, also, on the surrounding atmospheric temperature. If the pouring is done in a cold and exposed position, cooling will be rapid; if done in a hot room, such as a furnace room or foundry, cooling will be slow. The bearing shell should be heated before pouring, and the atmospheric temperature should be moderate; the observation of these conditions should help to obtain satisfactory results.

In all babbitting of bearings it is important that the shell be thoroughly cleaned and tinned before pouring; otherwise, the metal may not make a tight joint with the inside of the shell and shrink away when cooled. Also, with a solid union of the metal to the shell any heat generated between the shaft and the bearing will be conducted through the white metal to the shell and thence to the metal supports and dissipated by the large radiating surface. If the cleaning and tinning of the shell is not carried out properly, even assuming that the lining is securely fixed to the shell mechanically, the thermal conductivity will be bad and heat will not be transmitted between the white metal and the shell as it should be.

W. E. WARNER.
Shefford,
Bedfordshire, England.

Mounting Power Transmission Equipment Overhead from Special Steel Shapes

THE cost of erection of groundwork for mounting overhead equipment often seems quite high but an investigation shows that this is usually due to some structural conditions within the new building or extension. This is especially so when the building was not designed primarily for ease in mounting such overhead equipment. When such is the case, a considerable amount of extra millwright work is needed to provide groundwork for supporting the structural steel or wooden stringers to which the overhead equipment is attached. Millwright labor is high and because of its nature cannot be rushed. In some instances, this cost of erection has had a deterrent effect on the selection of lineshaft drives as opposed to direct motor-driven machines.

Plant engineers have found that the use of special steel shapes for the support of overhead machinery helps to keep this cost down. These shapes provide a flexibility in arrangement which cannot be obtained with wooden or standard steel shapes. Also, these special shapes can be installed very easily in any industrial building, whether the structure is of concrete, of brick and steel, or of the mill type. Figs. 1, 2 and 3 show applications of these steel stringers.

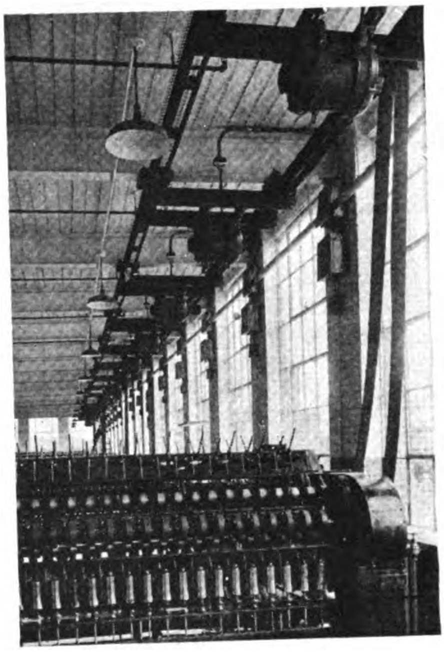


Fig. 3—Framework for mounting a line of fifteen motors.

Four men put up this steel groundwork and installed the line of fifteen 10-hp. motors in a day. The motor slides are mounted directly on the short cross-stringers and so provide for lateral adjustment to take care of belt stretch. Compare the cost and convenience of this method of mounting with that incidental to the erection of overhead platforms for the motors.

Many industrial operating men have a decided preference for placing motors, even up to 20 or 30 hp., on the ceiling. They also prefer to have them erected in what has always been considered the normal position, and therefore they construct platforms suspended from above, for mounting the motors. A motor, however, will run just as well upside down. There seems to be a growing tendency to dispense with the platform and attach the motors to the stringers in the reverse position. Fig. 3 shows a line of 10-hp. motors suspended in this manner from steel stringers in a large yarn mill. Steel stringers lend themselves to this sort of an installation just as well as to the mounting of lineshaft and countershaft hangers, as shown in Figs. 1 and 2. The stringers and motors shown in the illustration, Fig. 3, were set up in one day by four men. If necessary, this complete installation can be moved to another location or the units shifted slightly with very little time and trouble.

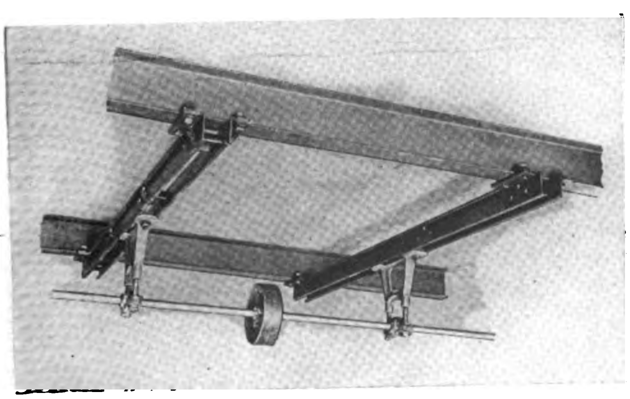
This steel stringer equipment effects a considerable saving in the erection of overhead equipment and greatly reduces the cost, in contrast to direct motor drives.

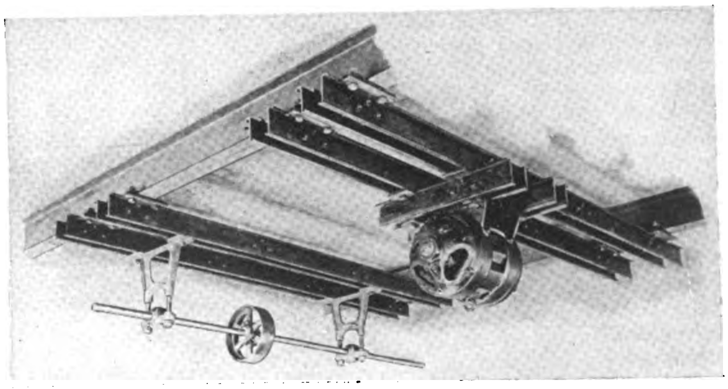
The extreme flexibility afforded by the use of these steel shapes, which are standard for all purposes of supporting equipment, greatly facilitates the machinery arrangement, particularly for new buildings. Irrespective of the relative position decided upon for the machinery, the line- and countershafting can be economically erected in the desired location under all building conditions. The necessity for making an elaborate transmission layout in the draftingroom beforehand is eliminated, although a rough layout is always desirable.

P. L. PRYIBIL.
Vice-President,
Midwest Steel & Supply Co.,
Bradford, Pa.

Figs. 1 and 2—Methods of mounting overhead transmission by using special steel stringers.

These two illustrations show how Midwest steel stringers are used for mounting shafting and motors to the steel I-beam ceiling structure. In one case the lineshaft is mounted parallel to the I-beams and in the other at right angles. The ease of erection and convenience of moving are two of the advantages of this style of structure.





In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Life of Bearings Increased by Individual Fit

IT IS a well-known fact that in most industrial plants more bearings are burned out from lack of lubrication than from ordinary wear. For this reason it is necessary to keep spare bearings in stock for motors on all important drives. These stock bearings can be used satisfactorily on new motors that have had reasonable care, but for all general purposes an individual fit should be given to each set of bearings, if long life is to be expected.

The responsibility for this important work should not be assumed by anyone or delegated to anyone other than a capable machinist who understands the principles involved. The time and money required to fit bearings properly are well spent in promoting higher efficiency and operating economy in the plant. The reliability of power drive equipment depends to a large extent on the condition of the bearings.

Birmingham, Ala. G. H. EMERSON.

How to Construct Handy Shelves For Shop Purposes

THE FACT that it is easy to nail a few boards together and pass them off as a shelf or rack probably accounts for most attempts at economy in the shop. If the matter of shelves or racks has been neglected or their purchase in the open market disapproved, a very cheap and durable shelf can be easily constructed in a short time. The material needed consists of angle iron and sheet iron, with some bolts and nuts, and the necessary tools.

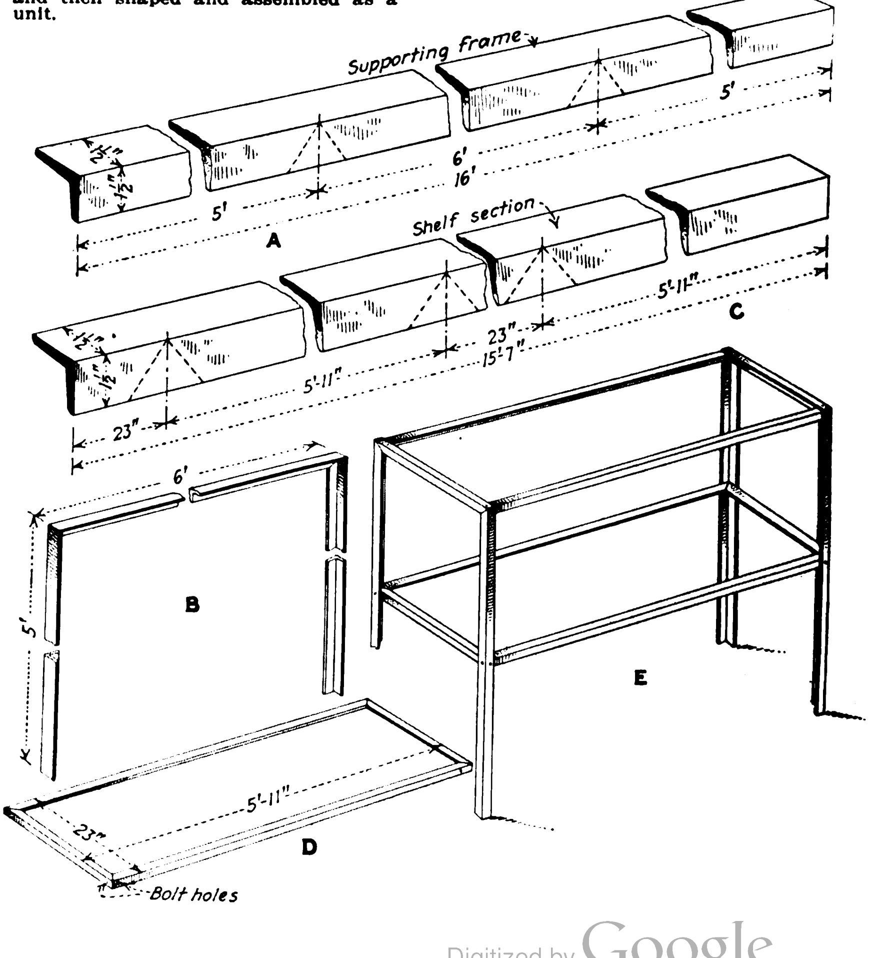
In laying out the shelf, first determine the length and height desired. If the height is assumed as 5 ft. and the length 6 ft., it would be logical to order angle iron 16-ft. long to avoid cutting. I have found that angle iron 1½ in. wide may be used for most purposes. On a 16-ft. length as shown at *A* in the illustration, measure off 5 ft. from each end and mark with a center punch. With this mark as a center line to the edge of the angle iron, cut out a 45-deg. wedge from each side of the mark. When these notches are cut in one side of the angle iron, it can be bent to shape the frame for the shelf, as shown at *B*. If the cuts in the angle iron have been made properly, they will fit when bent to shape and then may be welded together for strength. Each section of shelf will require two of these angle-iron units cut to exactly the same length—one for the front, and the other for the rear section.

On a unit 5 ft. high and 24 in. deep, I have found two shelves practicable for most purposes. The frame *C* for the shelf surface is laid out in the same manner as the supporting frame, and after preparation it is bent to shape as at *D*, with holes already drilled in the angle iron for the bolts. The assembly of the unit *E* follows, in which the front and rear supports are then bolted to angle-iron spacers of the same size and so arranged that the supporting spacer is used to form a natural shelf support. The shelf may consist of an ordinary piece of sheet iron, but where heavy materials must be supported, ¼-in. steel with a center brace is recommended.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.
Aurora, Ill.

A simple method of fabricating angle-iron shelf units.

The supporting members of the frame and the shelf surface are laid out according to the over-all dimensions, and then shaped and assembled as a unit.



Principal Factors Involved in Changing a Motor From Two to Three Phase

A PROBLEM was given me a short time ago concerning the reconnecting of a 5-hp., 220-volt, 60-cycle, Type C.C.L., 24-coil Westinghouse motor, connected two-path, two-phase, four-wire, for three-phase, 220-volt, 60-cycle operation.

This motor can be reconnected for 220 volts, three-phase, by cutting out approximately 20 per cent of the turns. The method of arriving at this conclusion is as follows:

The first step in changing from two to three phases is to find out what the series-delta line voltage would be, and next determine the line voltage with a series-star connection. Then select the most suitable connection from this combination.

The formula for changing from two- to three-phase, series-delta line voltage would be $C \times V \times 0.7$, where C is the number of paths or circuits in the two-phase winding, and V the two-phase line voltage. The series-star line voltage is found with the following

formula: C × V × 1.21, where C and V have the same meaning as used initially.

Then the three-phase series-delta line voltage should be 2 × 220 × 0.7 = 308 volts. The series-star line voltage would be 2 × 220 × 1.21 = 532.4 volts.

As 220 volts and three-phase operation is required, the best connection is a two-parallel star, which means that the line voltage should be 532.4 ÷ 2 = 266.2. This is 21 per cent higher than the line voltage obtainable under normal operating conditions for standard equipment.

To make the change there are two things that can be done: First, rewind the stator, reducing the turns per coil to 80 per cent of the present turns and increase the cross sectional area of copper 20 per cent. Second, regroup the coils for three phase and arrange the coils per group so that the phase insulation is satisfactory, that is, provide one coil at the end of each pole-phase group with additional insulation and cut out 20 per cent of the coils, which, in this case means that 24 × 0.80 = 19 active coils will be left in. But as 19 is not divisible by 3, the number of phases, an active number of coils must be selected that will give an equal number of coils in each phase and also permit uniform odd grouping.

If the motor in question had four poles there would be 12 pole-phase groups, and as a two-parallel connection is required, the number of coils in each parallel circuit or leg must be equal in number. Therefore, in this case, the number of active coils would have to be 18 for either a four- or six-pole motor, which means cutting out six coils.

Cutting out the coils does not mean that the rating should be reduced, as the coils or turns cut out are excessive and are not needed to develop the required line voltage. But what is more important is the current carrying capacity of the wire on the two-phase coils as the current per terminal for a three-phase motor is approximately 15.5 per cent higher than for the corresponding two-phase motor.

Thus, cutting out the turns does not alter the horsepower rating but does effect the I^2R losses and the final efficiency and power factor. The three-phase rating will then depend upon the design of the motor in question, that is, if the design is liberal, the horsepower rating with the three-phase grouping can be higher than where the design is close.

The efficiency and horsepower at the reduced rating should be slightly higher when coils are cut out, the amount depending on the design and other factors. But, when the turns and size of wire are altered correctly, then both ratings should be alike.

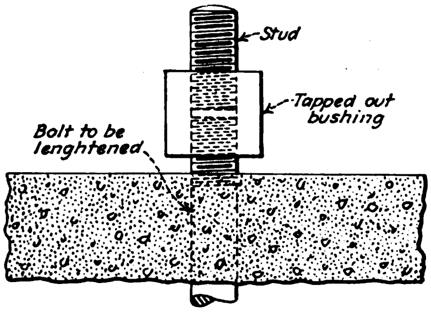
This subject is covered in more detail in Mr. A. M. Dudley's book, "Connecting Induction Motors," second edition.

A. C. Roe.

Renewal Parts Engineering Dept.
Westinghouse Electric & Mfg. Co.,
Homewood, Pa.

Bushing Method of Lengthening Anchor Bolts

NOT long ago it was necessary for us to raise a machine several inches above its original position due to changes made in the gearing. We were at a loss for a while to know just how we could use the same foundation bolts, which were too short after the machine had been raised. After considering putting in new bolts, it was decided to make a bushing connection as shown in the illustration.



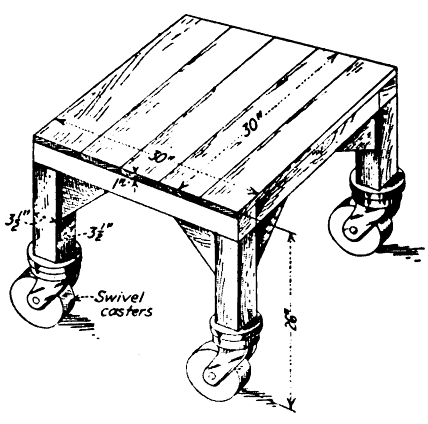
The old foundation bolts were lengthened by screwing steel bushings over them and then screwing stud bolts into the bushings.

We tapped steel bushings to the size of the bolts and screwed them down halfway on the original foundation bolts. Stud bolts were then made to correspond to the difference in length and these were screwed into the bushings, making the original foundation bolts the required length. The machine was set on the new foundation and put into service immediately. Considerable time was saved with this method, and we feel certain that it is a first-class job.

Denver, Colo. R. M. Thomas.

Bench Truck for Transporting or Repairing Motors

A FACTORY that is motor driven throughout has made the bench truck shown in the accompanying illustration, to transport the motors about as needed and for use as a temporary work bench. The plant has nearly a hundred a. c. motors of 2½- to 15-hp. rating in use and some spares.



This bench truck is used for transporting or for supporting motors while making repairs.

Sometimes the work to be done consists of nothing more than putting in a duplicate bearing or cleaning out a dirty oil well, but the location of the drive is such that the work can be better done with the motor up where there is sufficient light and working space. It has been found that time is saved by loosening the four bolts holding the motor, disconnecting the coupling, and getting the motor in a convenient position, rather than by attempting to do the work in a dark and limited space. Also, when the motor is up where it can be examined carefully, it can be cleaned more easily and worn insulation, or other defects which would be likely to cause trouble later, are often found, although they may not have been noticed on the preliminary examination in the darker or more inconvenient location.

In addition, this truck is used to transport the motor when it has to go to the shop for more extensive repairs. An advantage here is that the truck belongs to the maintenance department and so can be used without interfering with production work. The truck is substantially constructed and has No. 190-L Payson swivel casters under it, which, combined with its relatively small size, enables it to be pushed around easily and into places where other trucking or loading equipment would not go. When in the shop the motor may be repaired while on the truck, if no other motor is down, and its size and height lend themselves to convenient working.

The factory's woodworking department turned out this truck. The legs and rails are made of maple and a 1-in. maple floor is laid on top. Carriage bolts (not shown) were placed diagonally at the corners and braces added for further stiffness. Use has demonstrated that the truck was built for rough service and it has more than earned its cost.

Donald A. Hampson.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Wooden Case for Protecting a Pocket Compass

MOST electricians have in their tool kits a pocket compass which, due to its delicate construction, is very likely to be damaged if not protected. A compass case can be easily made, which will prevent damage to the instrument, and yet permit its use while it is so inclosed.

To build this case it is necessary only to bore out a block of wood so that the compass just fits into the case snugly. The block is then cut down so that there is a wall of wood approximately ½ in. thick around the compass. A cover which is so made that it can be turned to expose the compass dial will serve to finish up the case. It is not necessary to remove the compass from its case in order to observe the needle; so any danger of injuring the compass is very remote.

Chas. A. Peterson.

Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

New Equipment

for plant operation and maintenance

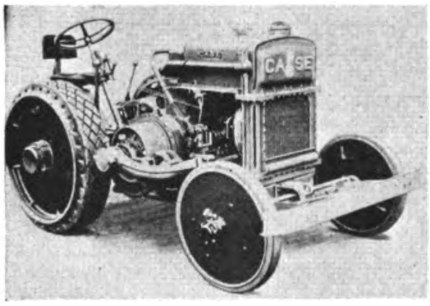
Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Industrial Tractor

AN ANNOUNCEMENT has been made by the J. I. Case T.M. Co., Racine, Wis., of their new industrial tractor, intended for use in factories, railroad shops, freight terminals, oil fields, lumber yards, road building and maintenance work, parks, logging camps, and elsewhere.

Because much of the work of such a tractor is in close quarters, this machine is built compact and low. Also, the great stability claimed for this tractor is due principally to its low center of gravity.

A radius of only 10 ft. is needed to turn the machine around completely and a quick-acting throttling governor regulates the speed of the engine.



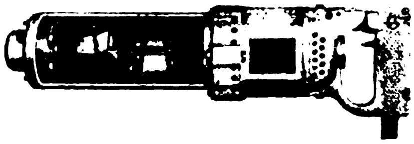
Case Industrial Tractor

The weight of the tractor is so distributed that approximately two thirds of it is borne by the rear wheels. These wheels are cast hollow so that, if necessary in very hard going, they can be filled with 400 to 500 lb. of sand for additional traction.

Portable Electric Hammer

THE ACCOMPANYING sectional view shows the internal mechanism of the new electric hammer announced by Black & Decker Mfg. Co., Towson, Md. The universal motor in this hammer is of the same type as used in the Black & Decker portable electric drills, with the exception of a few minor refinements that make it more applicable for this particular type of work. The motor armature turns at approximately 10,500 r.p.m. and is equipped with an aluminum centrifugal fan. Automatically adjusted ball bearings are used on the armature shaft.

The armature-shaft is hollow to accommodate the spline-shaft upon which the reciprocating hammer mechanism is mounted. This reciprocating mechanism, which actually strikes the



Black & Decker Electric Hammer

blow, is made up of a drop forging upon which are mounted the two beveled gears heavily weighted on one-half of their area. These gears are driven by a beveled pinion on the spline-shaft and rotate in opposite directions. When the two weights are together at the bottom, the reciprocating mechanism moves downward, striking a heavy blow on the oil-tight piston which transmits the blow to the drill or cutting tool. When the two weights come around together at the top, the reciprocating mechanism travels up with equal force, but the blow is absorbed by the coil spring.

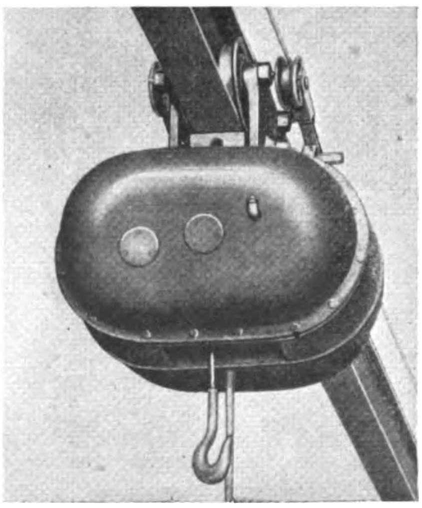
The hammer strikes 2,300 blows per min. The working mechanism operates in a bath of oil and is, therefore, sealed against dust and grit.

Electric Hoists

AN ALL-STEEL, quarter-ton electric hoist, adaptable for quick-lift service, has been put on the market by the American Engineering Co., Philadelphia, Pa.

This high-speed hoist has a pressed-steel frame with gears and shafts of chrome-manganese steel. In addition to the ball bearings and the non-spinning hoisting rope features, dependable serv-

American Engineering Co. High-Speed Hoist



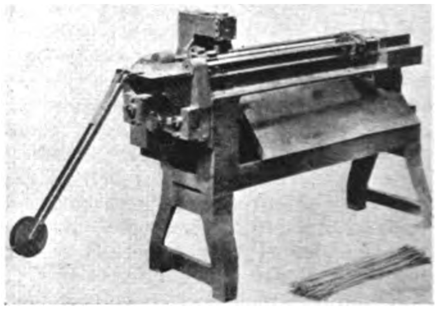
ice is made possible by the oil bath lubrication. All working parts are fully inclosed and the hoist is operated by a push-button control and upper and lower limit switches.

The hoist weighs 200 lb. and is made in two types—plain trolley and hook suspension. The plain trolley type requires 16 in. headroom and the hook suspension type 18 in.

Wire Cutter and Stripper

A NEW type of machine, which automatically measures wires into lengths, cuts them off and simultaneously strips the insulation from both ends, has recently been developed by the Artos Engineering Co., 69 Wisconsin St., Milwaukee, Wisc.

This machine is adjustable in regard to cutting lengths, stripping lengths, and size of wire. As it is claimed the capacity of the machine is very large, 3,600 pieces being cut and stripped per hour. Several operations are combined into one, thereby resulting in a considerable saving in labor.



Artos Automatic Wire-Cutting and Stripping Machine

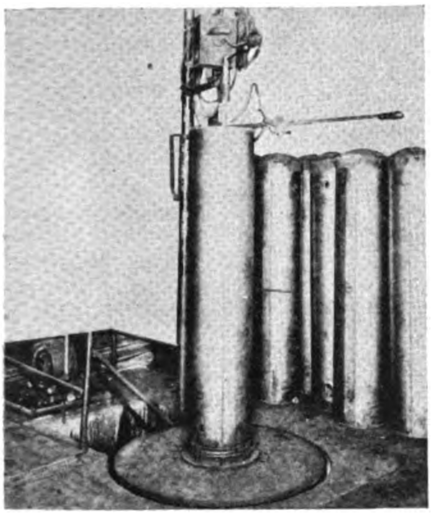
Automatic Welding Device

A NEW carbon arc-welding machine has just been placed on the market by the Lincoln Electric Co., Cleveland, Ohio. This equipment is designed for the purpose of welding bottom seams on cylindrical tanks.

The equipment is standardized for tanks up to 6 ft. in diameter and 8 ft. high, but special equipment may be furnished to handle any diameter or length of tank.

It is claimed that on 14-gage material a lap head seam, as shown on the tanks in the illustration, which have been welded, can be welded at the rate of 135 ft. per hour. Also, the edge weld used on the bottom of some types of range boilers may be welded at the rate of 150 ft. per hour, as the bottom is flanged and fitted so that the edges are together and flush with each other.

Tanks that are to have the bottom seams welded are set on a revolving table and the arm carrying the automatic welding head is adjusted to bring the arc on the seam. The spread of the revolving table is adjustable over a wide range to handle various sizes of tanks, and the welding current is also



Lincoln Automatic Bottom Welder for Cylindrical Tanks

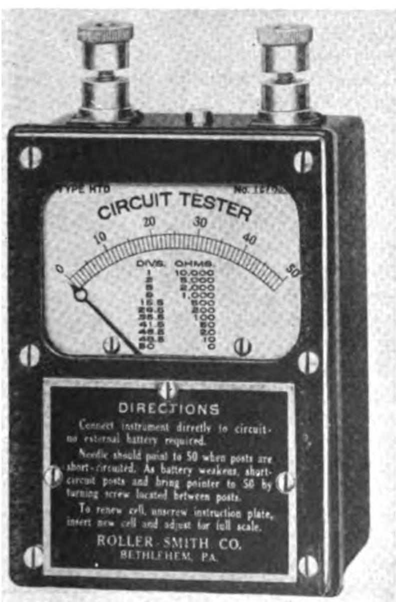
adjustable through the controls located on the welder control panel. An automatic stop and start control on the automatic welder head is provided for the operator.

Circuit Tester

A PORTABLE, direct-reading circuit tester, known as Type HTD, has been put on the market by the Roller-Smith Co., 233 Broadway, New York, N. Y. The uses of this instrument are twofold. It can be used to ascertain if there is an electrical circuit existing between conductors applied to the terminals of the instrument and it can also be used to obtain an approximate idea of the resistance of the circuit under test.

A small D'Arvsonal type d.c. voltmeter is used in series with a standard flashlight battery 1 in. in diameter by

Roller-Smith Type HTD Portable Circuit Tester



2 in. long. The instrument pointer will indicate full scale when the terminals are short-circuited. The scale is divided into 50 uniform divisions of arbitrary value. Directly below the scale is located a chart, by reference to which resistances up to 10,000 ohms may be calculated.

By removing three screws the instrument plate can be taken off and the dry cell replaced. The removal of this plate also gives access to the internal zero adjustment. The instrument weighs 19 oz. and is inclosed in a heavy sheet-metal case with black finish, which measures 4½x3x1½ in.

Push-Button Station

ANNOUNCEMENT has been made by the General Electric Co., Schenectady, N. Y., of a new push-button station for use in preventing the cutting out of motors controlled by a magnetic starter when there is a brief power disturbance. The station has two push buttons, "Start" and "Stop," and bears the G.E. designation CR-2940-BS-82-A.

The station is used with standard magnetic starters, making it unnecessary to add time-delay attachments to the starters themselves. When power fails the magnetic starter will, of course, drop out but will reclose upon the return of voltage by the action of the push-button device, unless the time for which the push-button station is set is exceeded, when the "Start" button must be pushed to energize the magnetic starter and restart the motor.

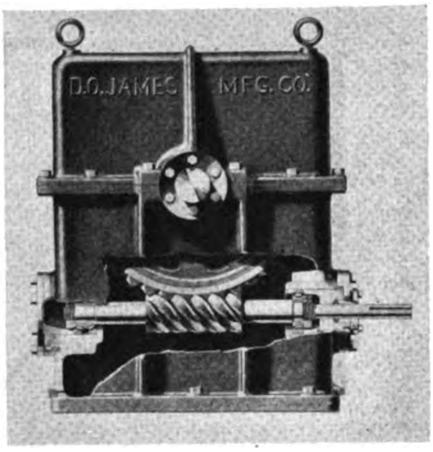
When the voltage drops sufficiently to permit the solenoid to release the plunger, the latter starts to fall, but is retarded in its downward movement by a rack which turns a gear. The gear engages a ratchet, which can be adjusted for a maximum of 1.5 sec. by means of a heavy nut at the end of a rod which serves as a pendulum.

If power does not return before the expiration of the time limit for which the device is set, the contacts will open and both the solenoid and magnetic starter will be disconnected until the "Start" button is again pushed.

Speed Reducers

THE NEW James heavy-duty worm-gear speed reducer, as illustrated, has been put on the market by the D. O. James Manufacturing Co., 1114 W. Monroe St., Chicago, Ill.

In this speed reducer, phosphor bronze gears, chrome nickel steel worms, Timken and Norma Hoffman roller bearings and interchangeable bushings are used. A lock nut and lock pin, which allow for easy adjustment, hold the thrust bearing in proper position on the worm shaft. A large heat radiating and oil cooling space in the housing keeps the oil at a low temperature, it is claimed, and the stuffing gland and the worm shaft can be easily replaced.



James Heavy-Duty Worm-Gear Speed Reducer

The housing is made of gray iron, designed for maximum oil cooling space, and braced on the outside for strength.

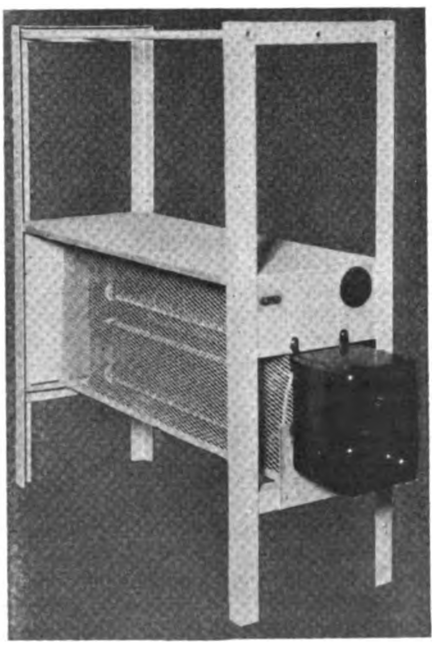
Electric Heaters

ANNOUNCEMENT of electric change-house heaters for use in the oil and mining fields and for use in building and construction work has been made by the Westinghouse Electric and Manufacturing Co., at Mansfield, Ohio.

These type HA heaters consist of an angle-iron and sheet-metal frame, two oven heaters being suspended under the shelf and protected by an expanded metal screen. A rack at the top is useful for holding clothing while drying, and the shelf may be used to warm lunches or for other purposes.

An oil-immersed switch is used for turning the power off and on, for ordinary applications where oil switches are not required, a WK-62 safety switch is

Westinghouse Type HA Electric Change-House Heater



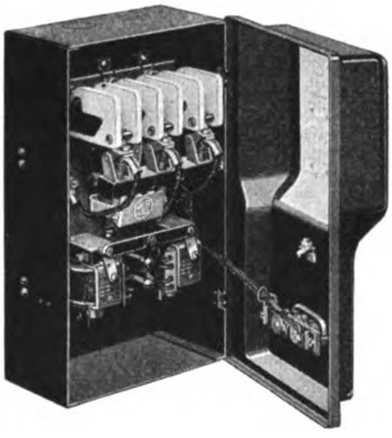
used. The power required is 10 kw., and either 220 or 440 volts, single phase, may be used. The apparatus is strongly constructed and weighs slightly over 100 lb. The overall dimensions are 18 in. x 50 in. x 50 in. high.

In special cases where warm water must be supplied, cast water coils are clamped on either side of the heaters. These will furnish a considerable amount of heated water and the stored heat in the castings is sufficient to warm water passing through the coils.

Push-Button Starters

THE Allen-Bradley Co., Milwaukee, Wis., has placed on the market a complete line of a.c. and d.c. push-button starters ranging from ¼ hp. to 10 hp., 220 volts, d.c. and 15 hp., 550 volts, a.c.

The a.c. and d.c. switches of similar rating have the same external dimensions. The covers on all starters swing to the side, and can be locked against tampering and injury to any employee



Allen-Bradley A.C. Push-Button Starter

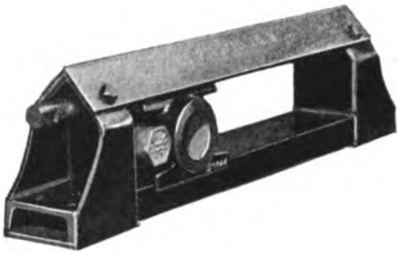
not authorized to open the box. All parts of the switch are readily accessible for inspection and ample room is provided for wiring.

The a.c. starters give protection against overload, no-voltage, and single-phase operation. An outside reset lever makes resetting of the inducto-therm relays convenient. Arc shields are used on all switches and magnetic blow-outs on the larger sizes of both a.c. and d.c. switches.

The d.c. starters, it is claimed, give positive starting, no-voltage, and overload protection. A special graphite compression register gives stepless acceleration until all resistance is cut out at full speed of the motor. The resistotherm relays are designed to give accurate overload protection.

Protected Screw Type Take-Up

IMPROVED design of the protected screw type take-up for heavy work and long-movement, to be known as Style DS, has been announced by the Link-Belt Co., 300 West Pershing Road, Chicago, Ill. Its details of construction and design conform with sound engineering practice, it is stated.



Link-Belt Style DS Protected Screw Take-Up

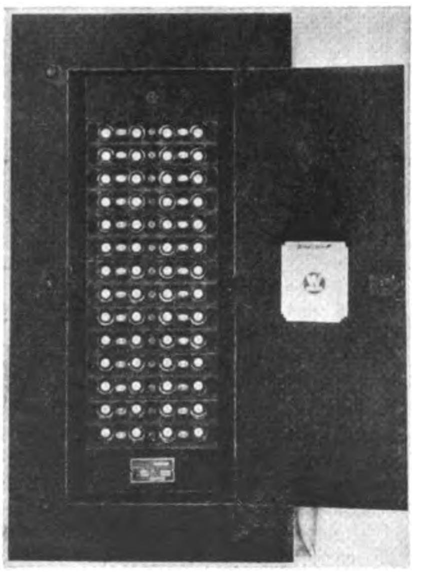
The frame is of welded structural steel with channel base welded to ends formed of steel plates, bent and welded into strong box members and in which the adjusting screw is mounted. The steel angle bolted on top of the ends protects the screw from dirt or the weather, in addition to tying the ends together, thus strengthening the frame and preventing upward movement of bearings. This feature is shown in the accompanying illustration. The protected screw remains fixed in position, and the nut for adjusting the movement of the bearing travels on the screw. The movement-adjusting screw does not project beyond the ends of the frame. The cast-iron bearing is lined with babbitt, is tapped for grease cup or pressure fitting, and is proportioned in length for each diameter of shaft, it is stated.

Plug-Fuse Type Panelboard

TWO new types of panelboards that are small, compact, and of the plug-fuse, full-safety type, have been introduced by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

These two new panelboards, known as Types JF and NJF, are built up of individual sections of black molded composition. Each section or block consists of eight plug fuse receptacles arranged for four circuits, double fusing, Type JF, or for eight circuits, single fusing, Type NJF.

New Westinghouse Panelboard of the Plug-Fuse Type

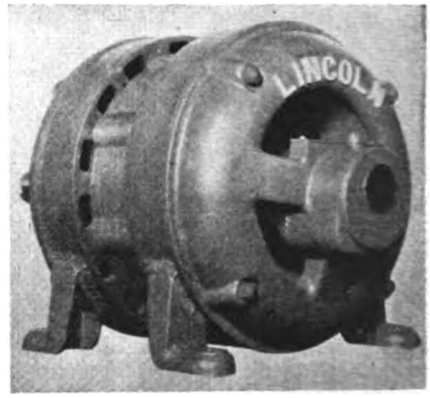


Main switches are of the rotary-brush contact type with quick-break mechanism breaking the current at two points. The handle of the switch is mounted on a cast faceplate. Adjustment of the panel and trim is accomplished by means of the adjustable corner irons and the Westinghouse indicating trim clamp. Any adjustment within a limit of ¾ in. can be made.

Welded Steel Motor Frames

WELDED steel motor frames are now claimed as a feature of the new motors manufactured by the Lincoln Electric Co., Cleveland, Ohio.

The construction of the new motors is an assembly of hot rolled steel parts welded into the equivalent of a casting. It is claimed that the welded steel method of construction gives a practically unbreakable frame, lighter weight and better ventilation.



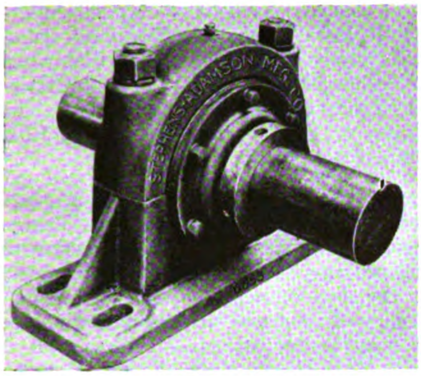
Lincoln Electric Welded Steel Motor Frame

Roller Bearings

A NEW bearing, called the super-service bearing, which is equipped with Hyatt anti-friction rollers, is manufactured by the Stephens-Adamson Manufacturing Co., Aurora, Ill. These journals are designed for bearing service where heavy loads are to be carried and where economy is of particular importance.

With these bearings two types of mountings are employed—the standard and adapter types. In the standard type, the shaft is turned to receive the inner race, which is pressed into place. The shaft may extend beyond the bearing through the housing cover at a diameter slightly smaller than that for the inner race, or it may be cut off and a closed cover used. The outer race is pressed into a spherical shell which is allowed to oscillate in a spherical seat in the base to correct any slight misalignment of the shaft. A plain annular collar is provided inside the roller inclosure for moderate thrust loads in one direction.

The adapter type is similar to the standard type except that special prep-



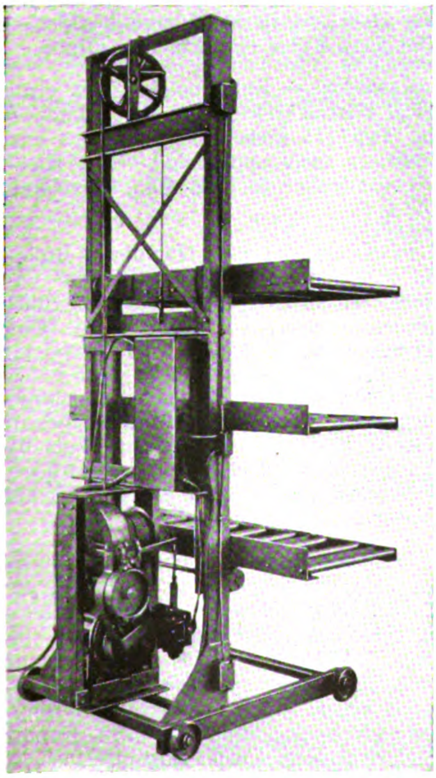
Heavy-Duty Stephens-Adamson Bearing

aration of the shaft is avoided by using an inner race bored to slip onto commercial stock shafting of the same diameter as the maximum extension for the standard type. The inner race is held in position and prevented from turning by two set-screwed collars engaging the ends of the race and extending through the housing covers to make the set screws accessible without disassembling. The closed cover cannot be used with the adapter type. The adapter bearing is especially applicable to interior locations on long shafts and as a replacement for plain bearings on old work.

Stacker with Roller Conveyor

CONSTRUCTION of a stacker that can be adapted generally in plants using roller conveyor systems has been announced by the Lewis-Shepard Co., Watertown Station, Boston, Mass. The platform of this stacker, as is shown in the accompanying illustration, is constructed with rollers similar to those used on conveyors. The stacker is used to bridge gaps where conveyors are on various levels, for elevating materials from, or lowering to, the floor, or for transferring material from one conveyor line to another where conveyors are on parallel levels, it is stated.

Lewis-Shepard Stacker with Roller Conveyor Platforms



The stacker can be powered with motors varying from ½- to 3-hp. rating. The unit is driven by an inclosed worm running in oil. The slacker is portable and is constructed of arc-welded structural steel.

This company has also developed a small hand power stacker for use in elevating heavy apparatus such as motors, heavy controllers, or other electrical equipment for mounting or removing from walls or machines, or holding in position while attaching.

Flexible Coupling

IMPROVED lubrication features have been added to the flexible coupling manufactured by the W. H. Nicholson & Co., Wilkes Barre, Pa. Previous announcement of this unit was made on page 42 of the January, 1927, issue of INDUSTRIAL ENGINEER. The coupling consists of two hubs on flanges keyed to the shaft. These flanges are connected by loose keys in the outer edge of the flanges. The entire coupling is incased in a two-piece shell.

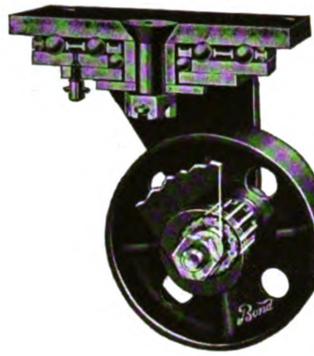
The improvement consists of holes that are drilled longitudinally through the floating keys and the hubs or flanges. These holes serve as reservoirs for oil. In addition, a lip is now extended from this casing over the left hub of the coupling and oil can be poured into this lip either while the coupling is idle or in motion.

With the added space provided by the holes in the lip, the coupling is said to carry approximately 150 per cent more oil than the older type. The improved type is known as Style A, and the old type without the oil lip is designated as Style B.

Swivel Truck Caster

IN THE new Ajax swivel truck caster illustrated, which has been placed on the market by Bond Foundry & Machine Co., Manheim, Pa., three sets of ball bearings are provided in the caster. In the 8-in. caster, for example, a machined ball race with 16 steel balls is set near the pin to take the radial load when swiveling.

In addition, two machined ball race grooves take the load and assist in making swiveling easy. The outer race has 24, and the inner race 13, ⅝-in. chrome steel balls. The wheel revolves on solid steel rollers spaced by a steel retainer. The caster is made with 6-in. or 8-in. wheels. Either Alemite lubrication or an automatic oiling wheel, which is provided with an oil reservoir with a felt oiler, may be obtained.



Bond Ball and Roller Bearing Swivel Truck Caster

The manufacturer states that this is practically an all steel caster; the caster except for the semi-steel wheels is of open-hearth steel.

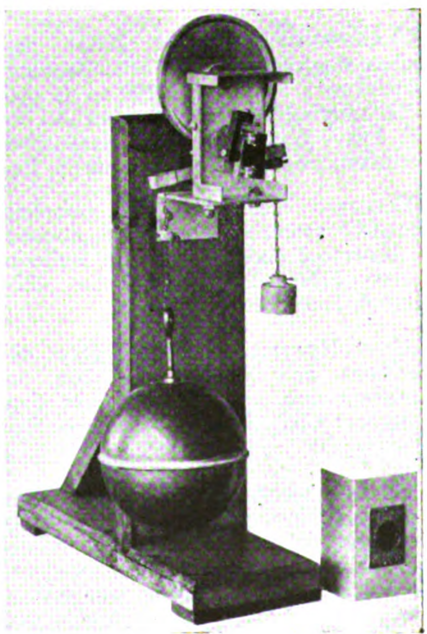
Float Switch

ANNOUNCEMENT has been made by the General Electric Co., Schenectady, N. Y., of a new float switch bearing the designation CR-2931-P, for use in control circuits only. This switch, in general, will be used to control the line contactor of alternating or direct-current automatic starters. It has a capacity for handling one 600-amp., two 300-amp. or four 150-amp. a.c., or d.c. contactors at from 110 to 550 volts.

A very simple design is employed. No castings are used, and a double contact eliminates shunts. It is claimed oxidation trouble has been eliminated by the use of silver contacts. The contacts are held by a moulded Bakelite arm that obtains its snap action in opening and closing the switch through a special mechanism.

The switch may be attached directly to a support extending across the tank or by means of a suitable side bracket.

G.E. Float Switch



Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

GREASE LUBRICATION—A general discussion of the importance and advantages of lubrication together with an explanation of the Keystone method are contained in the brochure entitled, "Keystone ABC."—The Keystone Lubricating Co., Philadelphia, Pa.

POWER CONTROL—Bulletin No. 11 describes and illustrates the "Edmoore" power demand limitator. This electrical device automatically controls and limits the power demands or peak loads on electric systems.—Edward T. Moore, 500 Cahill Bldg., Syracuse, N.Y.

BATTERY CHARGING EQUIPMENT—Battery charging control and protective devices are set forth and illustrated in bulletin GEA 817.—General Electric Co., Schenectady, N. Y.

LIGHTING—The 1927 edition of the Holophane Datalog, compiled by the Holophane engineering department, contains much information of interest to prospective buyers of lighting equipment.—Holophane Company, Inc., 342 Madison Ave., New York, N. Y.

CARBON BRUSHES—Catalog No. 5 contains engineering data covering the various grades of brushes manufactured by this company.—Electro-Nite Carbon Company, Philadelphia, Pa.

HEAT SAVING APPLIANCES—"A Word to the Wise" is the title of a booklet describing the Heat-Cop. heat saving appliance.—Heat-Cop. Corporation, Mutual Bldg., Richmond, Va.

TRANSFORMERS—Leaflet 20331 describes single-phase, platform mounting transformers for from 2,300 to 66,000 volts, ranging in capacity from 201 to 500 kva.—Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

ELECTRIC HEATERS — The complete line of Chromolax air heating equipment is illustrated and described in Bulletin C-108.—Edwin L. Wiegand Co., 422-First Avenue, Pittsburgh, Pa.

UNIT HEATERS—Serial 70 gives dimensions and performance data on Autovent unit heaters.—Autovent Fan & Blower Co., 730-738 W. Monroe St., Chicago, Ill.

GEARS—A collection of bulletins with loose-leaf binding describes the complete line of Sykes cut gears, of herringbone and straight-tooth types, speed reducers and a considerable amount of engineering data concerning gears and reducers.—Farrel Foundry & Machine Co., Buffalo, N. Y.

FIRE DETECTING EQUIPMENT—"Automatic Fire Detection" is the name of the new booklet describing the Garrison Automatic System.—Garrison Fire Detecting System, Inc., 79 Madison Ave., New York, N. Y.

MOTORS—Form No. 651 illustrates the construction of the stator and field windings on Century Type RS motors.—Century Electric Co., 1806 Pine St., St. Louis, Mo.

UNIT HEATERS—A folder illustrated a number of applications of Ilg unit heaters and their construction. — Ilg Electric Ventilating Co., 2642 N. Crawford Ave., Chicago, Ill.

MELTING POTS—A new leaflet, No. L-1868-B, has been released describing the Westinghouse automatic electric melting pots.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

METAL HOSE—The 12 page bulletin No. 201-29-C contains illustrations, data and descriptions of Cory seamless metal flexible hose.—Chas. Cory & Son, Inc., 183-87 Varick St., New York, N. Y.

ELECTRIC DISTRIBUTING APPARATUS — Catalog No. 27 describes and illustrates the "Bull Dog" line of electric power and light controlling and distributing apparatus.—Bull Dog Electric Products Co., Detroit, Mich.

SAFETY STAIR TREADS—Various applications of Wooster safe groove treads and security nosings are set forth in folder 14-d-1.—The Safety Stair Tread Co., Wooster, Ohio.

BELTING—A catalog and belting reference book of leather belting, belting accessories, mechanical leathers and leather specialties has been released by this company.—Chicago Belting Company, 113-125 North Green St., Chicago, Ill.

FIRE BRICK—The October issue of the Laclede-Christy Bulletin contains some interesting installation of fire brick made by this company.—Laclede-Christy, St. Louis, Mo.

COMMUTATOR STONE—Folder S2 announces the advent on the market of the new Acme Oxidizing Stone for commutators and collector rings.—Green Equipment Corp., Monadnock Block, Chicago, Ill.

TRAMRAIL SYSTEMS—Several interesting installations of Cleveland tramrail systems are described and illustrated in Folder No. TR 557.—Cleveland Electric Tramrail Division of The Cleveland Crane & Engineering Co., Wichcliffe, Ohio.

SHORT-CENTER DRIVES — A 16-page booklet, entitled "The Trend in Transmission," contains a brief discussion of engineering fundamentals and progress in the development of power transmission, with especial attention to the use of short-center drives. — Pullmax Division, Bird Machine Co., South Walpole, Mass.

WIRE ROPE — A brochure entitled "Modern Wire Rope" contains interesting data on the various types of wire rope and their application, together with engineering data required in their use.—Williamsport Wire Rope Co., Williamsport, Pa.

EXPANDED METAL — A folder shows by sketches 25 practical uses for Steelcrete industrial mesh in the plant.—The Consolidated Expanded Metal Co., Steelcrete Bldg., Wheeling, W. Va.

FLEXIBLE STEEL MATS — The use of the Acme mat in oily or slippery places around machinery is covered in a circular. These mats made in rolls are also used for conveyor belts, it is stated. —Acme Steel Co., 2840 Archer Ave., Chicago, Ill.

TRUCK CASTERS—Construction of the ball-bearing swivel and roller-bearing wheel in the Bond Ajax swivel truck caster is given in booklet R-5.—Bond Foundry & Machine Co., Manheim, Pa.

FIRE EXTINGUISHERS—The complete line of Fyre-Fyter carbon-tetrachloride, foam, and soda-acid fire extinguishers are described in a 32-page booklet.—The Fyre-Fyter Co., Dayton, Ohio.

RESISTORS — Bulletin 940 gives electrical characteristics and other data on the Type H nickel-alloy resistors and discusses their application.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

FLEXIBLE FIXTURE HANGERS—Bulletin 2102 describes and prices the various types of Crouse-Hinds flexible, fixture hangers. — Crouse-Hinds Co., Syracuse, N. Y.

SAFETY SLINGS — Illustrations showing uses of some of the various types of wire-rope slings for handling loads by cranes are given in a four-page folder. —Murray Safety Sling Co., Inc., 34 Water St., Pittsburgh, Pa.

OIL SWITCHES AND CIRCUIT BREAKERS—Engineering data on the Type E-20 Condit oil switches and circuit breakers of three-pole, 60-cycle rating, for 400 amp., 2,500 volts or less, in the manually-operated, automatic or non-automatic types, for flat surface mounting, are given in bulletin 472. — Condit Electrical Mfg. Corp., Boston, Mass.

Volume 85 New York, December, 1927 *Number* 12

INDUSTRIAL ENGINEERING

with which is consolidated

INDUSTRY ILLUSTRATED

Founded in 1882 as Electrical Review.
Consolidated with it—Western Electrician and Industry Illustrated.

Electrical, Mechanical and Plant Service in Industry

Contents

Departments

An IDEA *a* DAY

This is the last month of 1927. The new year will be here before we know it. Here is a suggestion that we have to make to you for the coming year.

Resolve to find a good idea each day that can be applied to your own daily work or that you can pass along to some one else in the plant.

Ideas are what make men grow bigger in responsibilities and in earning power. Ideas are what make industrial plants prosper and stay prosperous. They are the most powerful things that we have to do with.

Feed ideas to your job and to your plant, to make them both grow big. You will find lots of good ones in the editorial and advertising pages of Industrial Engineering.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y.

JAMES H. McGRAW, President
JAMES H. McGRAW, Jr., Vice-Pres. and Treas.
MALCOLM MUIR, Vice-President
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
C. H. THOMPSON, Secretary

WASHINGTON, National Press Building
PHILADELPHIA, 1600 Arch Street
CHICAGO, 7 South Dearborn Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Bldg.
SAN FRANCISCO, 883 Mission Street
LONDON, 6 Bouverie St., London, E. C. 4

Member Audit Bureau of Circulations.
Member Associated Business Papers, Inc.

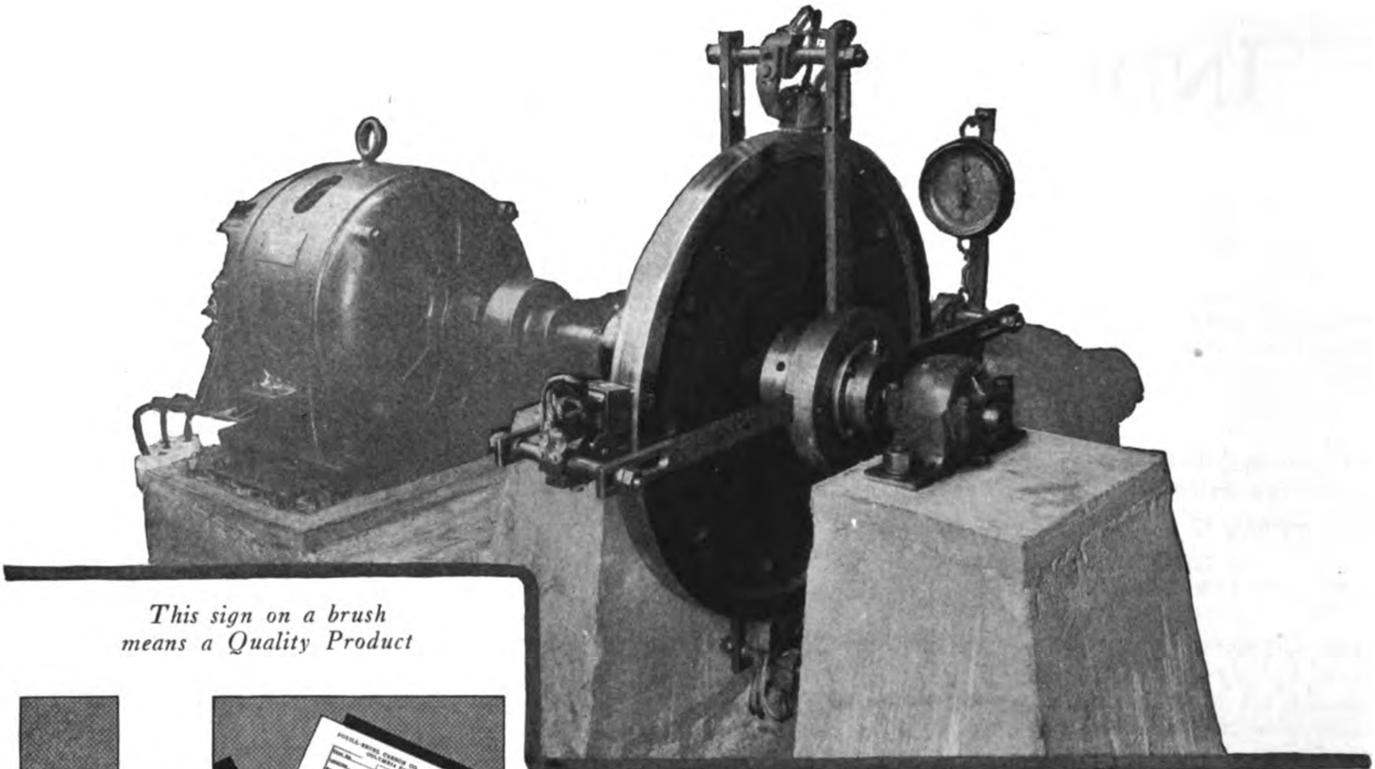
NEW YORK District Office, 285 Madison Ave.
Cable Address: "Machinist, N. Y."

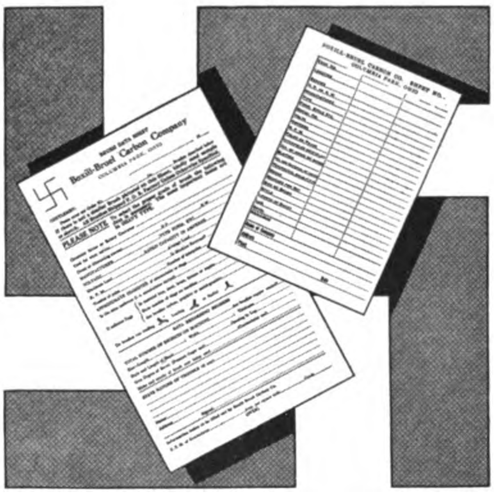
Publishers of

Engineering News-Record	American Machinist
Power	Chemical and Metallurgical Engineering
Coal Age	Engineering and Mining Journal
Coal Age News	Electrical Merchandising
Ingeniería Internacional	Electric Railway Journal
Bus Transportation	Construction Methods
Electrical World	Radio Retailing
Industrial Engineering	Electrical West *(Published in San Francisco)*

American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.





INDUSTRIAL ENGINEERING

with which is consolidated

INDUSTRY ILLUSTRATED

Electrical, Mechanical and Plant Service in Industry

Volume 85 NEW YORK, DECEMBER, 1927 *Number 12*

A Bigger and Better Service to Our Old and New Friends

. . . . With this issue *Industry Illustrated* which has been acquired by the McGraw-Hill Publishing Company, Inc., from the Engineering Magazine Company is consolidated with *Industrial Engineering*.

. . . . The consolidation marks the beginning of a fully rounded and better editorial service to that vitally important group of men comprising the Service to Production.

. . . . In this group are the plant engineers and their collaborators, the chief electricians, master mechanics, materials handling engineers and superintendents of maintenance of buildings and equipment, and others, of whatever title, in all of the various industries in which the functions of power transmission, power application, materials handling, maintenance of plant equipment, and other numerous services are common problems.

. . . . These men, in performing the important work which comes under their supervision, find their responsibilities with respect to equipment divided into four heads — Selection, Installation, Operation and Maintenance. They exercise wide control of these four functions with respect to facilities and equipment tributary to production in all industries. They are responsible for the electrical and mechanical transmission apparatus, the motorization, the mechanical handling equipment, the facilities for lighting, heating and ventilating, and other classes of fixed and portable equipment which serve and aid production. They are charged with the responsibility also in many cases of keeping the actual production machines themselves in condition for maximum service through proper installation and maintenance.

. . . . For while production machinery, unlike equipment tributary to production, varies widely according to the industry concerned, the methods employed and the proper organization for good maintenance are common to all.

. . . . In addition, these men of the Service to Production usually find themselves responsible for the maintenance of buildings and structures. Altogether, they have a big job, and one that deserves all the help that a carefully planned, well-rounded industrial publication can render.

. . . . The consolidation of INDUSTRIAL ENGINEERING and INDUSTRY ILLUSTRATED is a big forward step toward giving these

men the adequate and effective editorial service that their importance demands.

. . . . INDUSTRIAL ENGINEERING brings to the combination a background of thoroughness and technical accuracy that is indispensable and a unique record of service to its readers, particularly in the field of electrified services. This treatment will be maintained and expanded, for electrical transmission, control and motorization permeate the entire structure of modern industry and an understanding of electrical technique and its developments is indispensable not only to the industrial electrician but also to those whose chief interests lie with the associated mechanical systems.

. . . . On the other hand, electrification in industry is one important means to an end, that being the establishment of the most economical, reliable and efficient means of doing the job of providing service to production. Mechanical means to this end are and must be inseparably interwoven with the electrical aspects in the daily thinking of the men who form this group. Electrical power transmission and mechanical power transmission go hand in hand in the factory. Mechanical handling or shop transportation is largely an electrified job. Motorization and control are important aspects of nearly every modern mechanical system.

. . . . The plant engineer and those with and under him are confronted daily with the problem of co-ordinating the electrical with the mechanical. To serve these men adequately this publication must maintain an adequate and rational editorial balance and coverage of electrical and mechanical subjects in their relation to the Service to Production.

. . . . INDUSTRY ILLUSTRATED brings to INDUSTRIAL ENGINEERING a wealth of experience in the editorial treatment of materials handling, mechanical transmission and the utilization and care of miscellaneous plant facilities and building and plant structure maintenance. It brings also rich possibilities for more effective presentation through the use of the pictorial idea, in those cases where pictures can convey ideas to the practical man more readily than words.

. . . . This treatment, however, will be in addition to and not at the expense of the more detailed editorial treatment which has proved so valuable to the readers of INDUSTRIAL ENGINEERING.

. . . . Beginning with the January issue, *Industrial Engineering with which is consolidated Industry Illustrated* will be published by the McGraw-Shaw Company which is a subsidiary of the McGraw-Hill Publishing Company, Inc., and the A. W. Shaw Company. This is not a merger of the parent publishing companies, but a subsidiary which brings together unusual facilities, experience and viewpoints. It permits of the development for this paper of an informational program of greater usefulness than either publication could have otherwise attained.

. . . . You will welcome, as we do, this opportunity to provide, in one bigger and better publication, a fully rounded and intensely practical editorial service for the men who keep Industry's wheels turning, its materials and products moving, and its plants and equipment in fighting trim.

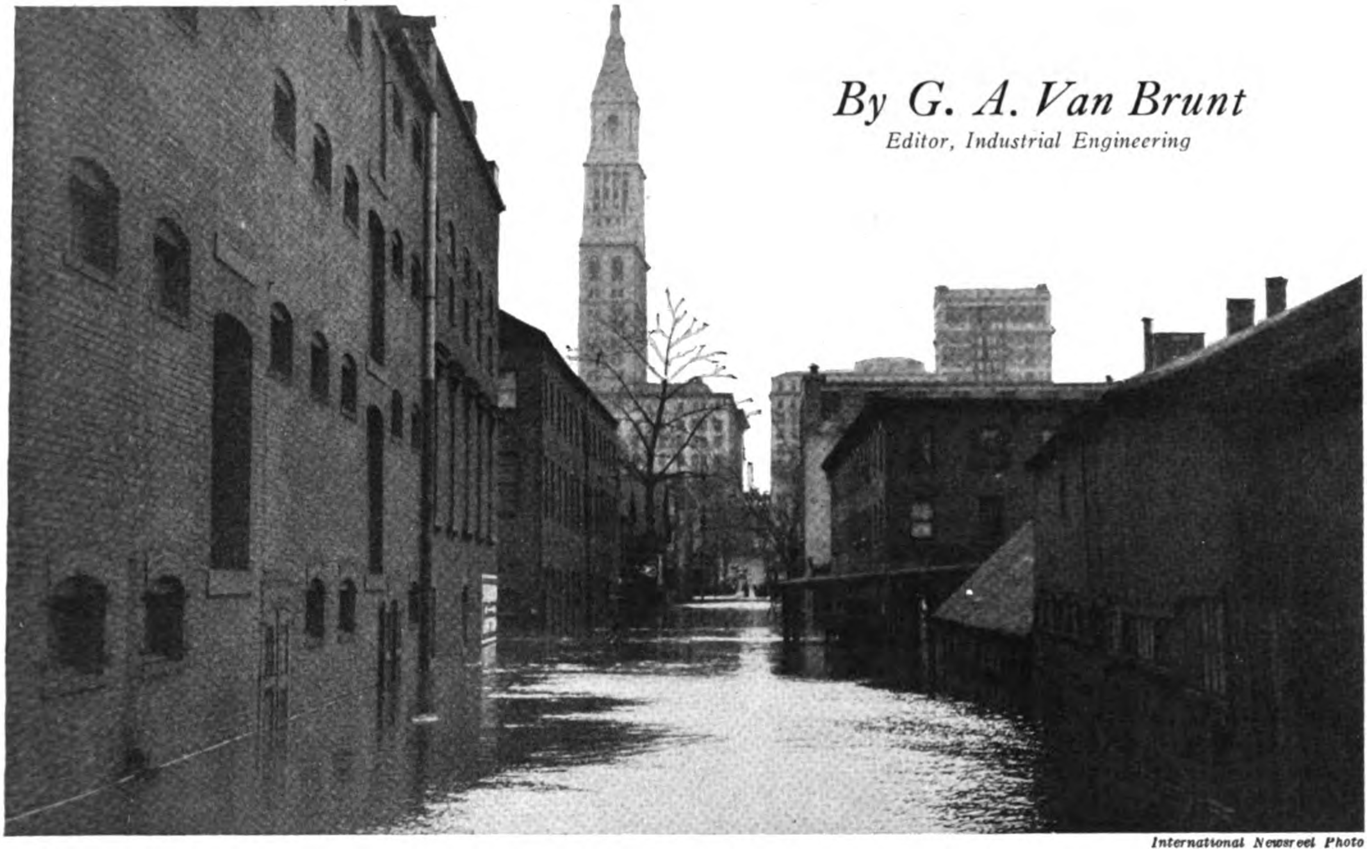
McGRAW-HILL PUBLISHING COMPANY, INC.

James H. McGraw

President

WHAT A FLOOD MEANS

to the Plant Engineer



By G. A. Van Brunt
Editor, Industrial Engineering

International Newsreel Photo

Fig. 1—When the Connecticut River invaded the streets of Hartford, Conn., flooding basements and ground floors of many establishments

WHEN a warm South wind met a cold North wind about the first of November, there ensued, over the New England states, a record-breaking rainstorm that lasted about 36 hours. Rivers reached stages seldom if ever exceeded and the resulting floods swept through towns and cities and countryside, causing damage estimated at nearly $30,000,000, and taking toll of between 80 and 90 lives. Houses, bridges, even two or three small villages were swept away as by a giant hand. Industrial plants in many cities were badly damaged and a few were completely destroyed. From all of them come interesting stories of rare devotion to duty, forgetfulness of self in the presence of danger and many examples of the rare ingenuity that plant men unfailingly display in emergencies, even when there is little time for action and less, or none at all, for thought. Precautionary measures that were taken to prevent damage to equipment, and methods employed to put water-soaked apparatus into operating condition, will be discussed in the following paragraphs.

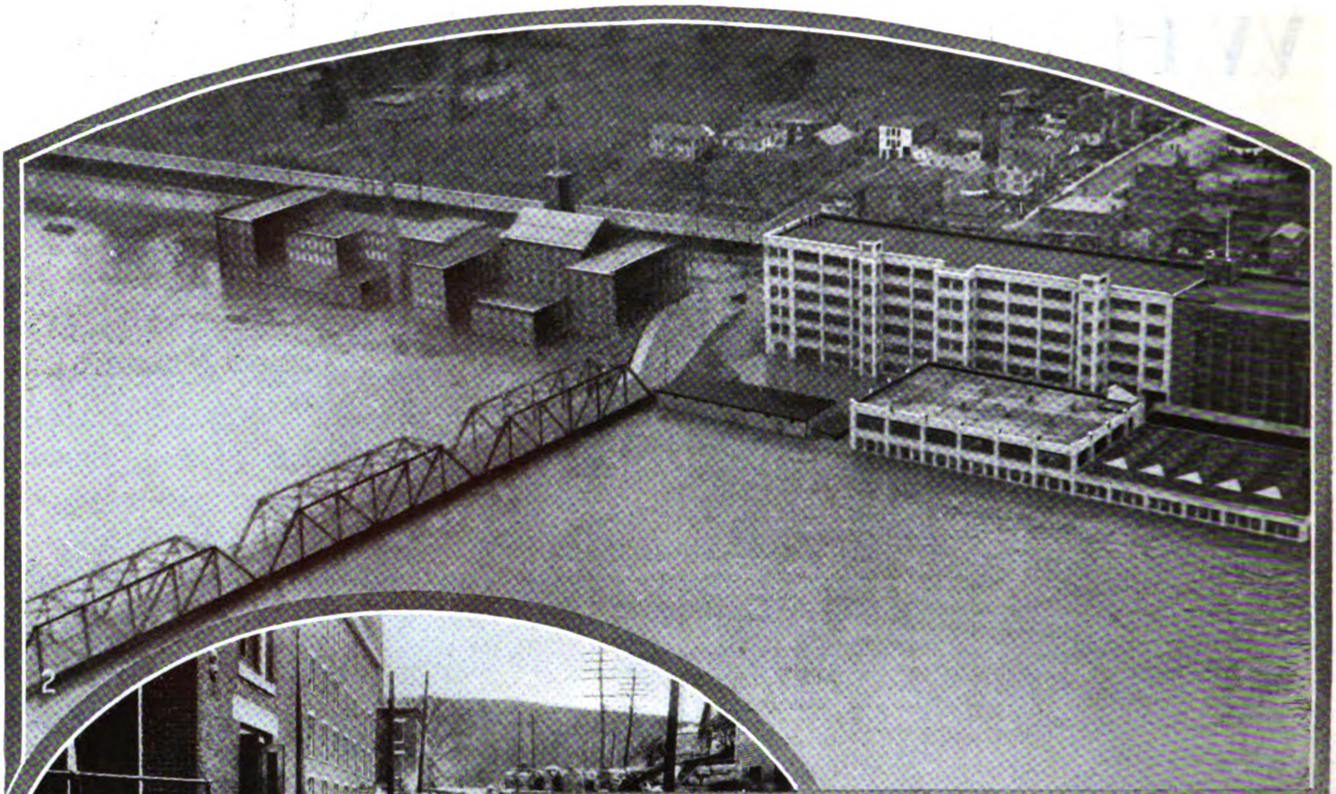
As might be expected, industrial plants did not have much warning that a flood was coming. At Windsor Locks, Conn., for example, a number of plants are built on the banks of the Connecticut River. A considerable rise is expected every Spring and occasionally at other times, but as a rule no serious damage results.

When the river began to rise as a result of the heavy rain, it was confidently expected that the normal Spring flood stage would not be exceeded. Within two or three days the river was several feet higher than this. In consequence, basements and ground floors in some plants were under 2 or 3 ft. of water.

In one large paper mill all of the motors mounted on machines or near the floor in the basement were unbolted and lifted up a short distance by chain hoists, when the water reached the floor level. Within a few hours the water had risen so high that it was necessary for men, working in hip boots or on rafts, to raise the motors as high as the blocks would lift them. In a few instances holes had to be cut in the ceiling and motors pulled through to the floor above, to keep them out of the water.

It was thought at first that the starting compensators were mounted high enough to be out of danger. However, when it was found that this was not the case, it was impossible to move them and they were submerged.

The switchboard stood in about 3 ft. of water at the height of the flood, but beyond removing some watt-hour meters mounted on the lower panels, nothing could be done



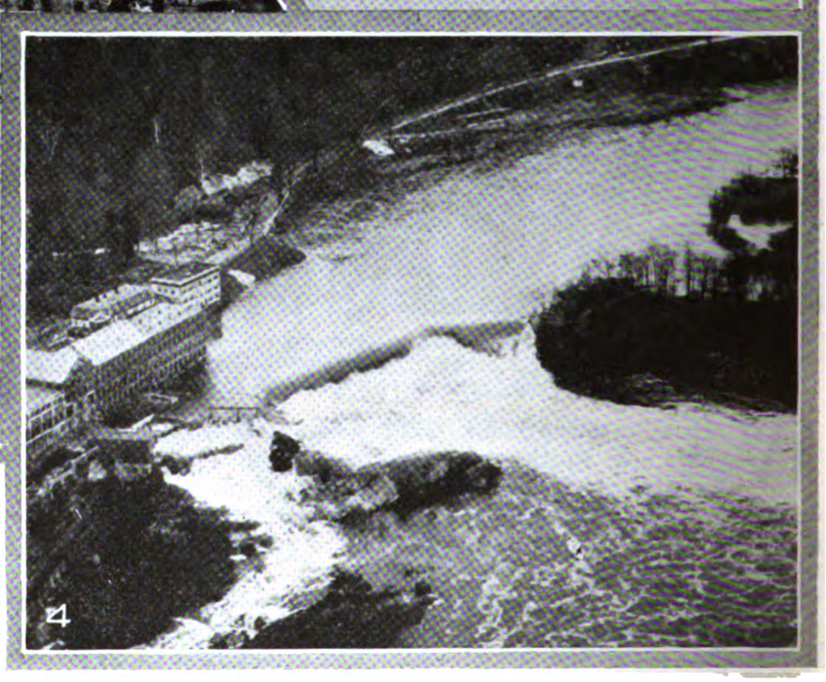


FIG. 2—AN AIRPLANE VIEW OF THE CONNECTICUT RIVER AT WINDSOR LOCKS, CONN.
P.&A. Photo

FIG. 3—A STREET IN NORTH ADAMS, MASS., AFTER THE FLOOD SUBSIDED
In the cotton mill at the left the water was about 1½ ft. deep.

FIG. 4—WHEN THE FLOOD WAS AT ITS HEIGHT, AT WORONOCO, MASS.

to protect it. This mill generates most of its own power, and, with the boiler room flooded, no light or heat was available until the water went down.

When steam was gotten up, the compensators were taken apart and cleaned and the coils dried out for three days over steam coils. The same procedure was followed in the case of the oil switches on the board. In the meantime, the switchboard was taken down and all equipment thoroughly cleaned and dried.

Flood water always contains a large amount of very fine clay that penetrates into bearings and is difficult to remove. When machines of any kind have been submerged, it is necessary to take them apart and clean them carefully, especially the bearings.

In this paper mill the reconditioning process required one week of strenuous work. However, when operation was resumed no trouble was experienced with any of the electrical or other equipment.

In a large textile mill adjoining this plant only a small amount of electrical equipment was located in the basement and, with the exception of a large generator, it was moved to a safe place. The generator, which is mounted over a pit, was protected from the water by a thick wall of sandbags piled all around it.

Naturally, a considerable amount of water seeped through the sandbags and collected in the pit. However, it was pumped out from time to time by a pumper borrowed from the city fire department. Although the water was about 3 ft. deep in the room, the generator was kept dry.

The Springfield area, particularly West Springfield and Westfield, was badly hit by the flood. As in the case of some other districts, the failure of a dike greatly complicated a situation that was already bad.

In West Springfield, a large area of low-lying land contains a number of good-sized industrial plants, and is protected from the Agawam River by an earthen dike.

After the Agawam River had risen to an alarming height, word was received that the crest of the flood had been passed. In some plants at least, the danger was considered to be over, and no further precautions were taken. Then, early Saturday evening, the dike failed a short distance above the point where the Agawam flows into the Connecticut River, and a wall 10 or 15 ft. high of swirling, muddy water washed over several square miles of territory.

A paper box factory was one of the first plants to be engulfed. The water rose about 9 ft. in the office and factory. Two employees barely saved their lives by climbing up to the roof of the single-story plant and were taken off in rowboats. There was no time or means of protecting equipment or stock and damage was very heavy.

In an adjoining plant manufacturing gears and light metal parts, several machine operators did not have time to stop the motors before they

FIG. 5—THE CURIOUS FOUND A THRILL IN WATCHING THE CONNECTICUT RIVER RISE AT HARTFORD, CONN.

International Newsreel Photo

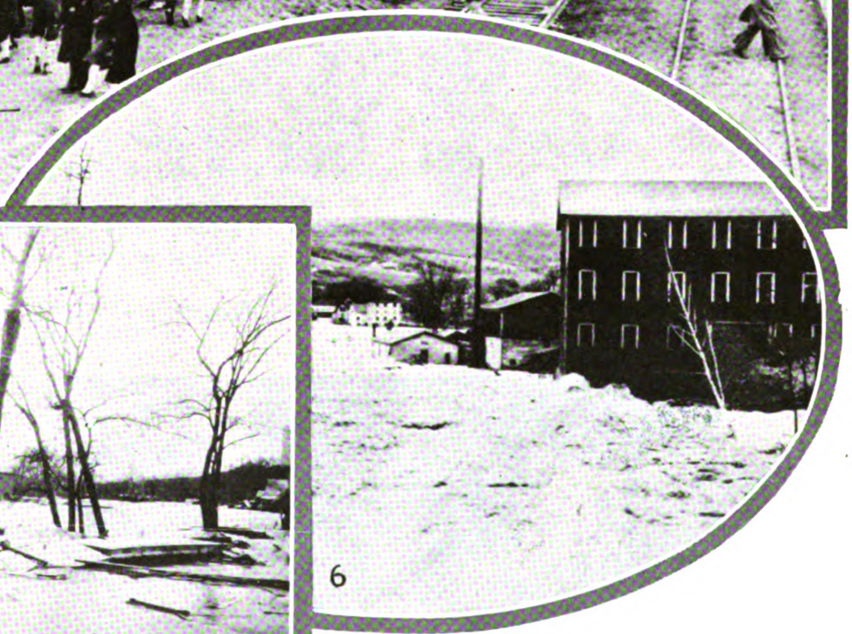


FIG. 6—FLOOD WATER TRANSFORMED THE PASSUMPSIC RIVER INTO A RAGING TORRENT AT ST. JOHNSBURY, VT.

Underwood & Underwood

FIG. 7—ANOTHER STREET IN NORTH ADAMS, MASS., BORDERING THE HOOSIC RIVER

FIG. 8 — THE SHIPPING PLATFORM OF A PLANT AT WEST SPRINGFIELD, MASS.

Later this switch engine furnished steam for a turbine-driven centrifugal pump that was used to remove the water from three tunnels that carry steam and power lines to the various plant buildings.

had to take refuge on the roof of the plant. When the water struck the bare conductors carrying power at 13,200 volts to the outdoor substation, the primary circuit breakers were tripped, thus cutting off the power and probably preventing serious damage to the motors.

The water rose to a height of 7 ft. 2 in. in this plant, so that all production tools and electrical equipment, including 22 motors and 20 starters, were totally submerged. At the end of three days the water was still about 2 ft. deep. However, as soon as it was possible to reach the plant by rowboats a gang of men was sent in and as a first step turned the fire hose on the machines, to wash off the heavy coating of mud. When the water finally receded it left a layer of clay-like mud 2 or 3 in. thick on the floor. As much as possible of this was flushed out with the hose, and sawdust was then scattered thickly over the floor. After a short time this was scraped off and another layer put on. This process was repeated until the floor was clean and then chloride of lime was sprinkled around as a disinfectant. It was realized that the flood water contained a large amount of sewage.

Sawdust was also shoveled over the machines to dry them off, before they were dissembled for a thorough cleaning. All bearings were taken down, cleaned, and fresh oil put in.

In the absence of a baking oven the motors and starting equipment were taken apart and dried out over improvised salamanders. When a 50,000-ohm magneto rang clear, the motors were put back on the line and after a week of operation had given no trouble. Although this method of drying out motors is hardly to be recommended except in a grave emergency, it appears to have been successful here, possibly because most of the motors were only a few months old and the insulation was in good condition.

Switches and starting equipment were taken apart and cleaned and coils dried out in the same manner as the motors. No trouble was experienced when the equipment was put back into service.

Conduit lines were, of course, flooded. As the quickest way of getting them into service, the wires were pulled out, wiped off, and dried. Swabs of waste were then pulled through the conduit, in order to remove the mud which filled them, after which the wires were again drawn in.

In this plant it was important to get production started as soon as possible. Consequently, while the electrical equipment was being reconditioned, a Fordson tractor was pressed into service to drive one of the main lineshafts. Production was resumed on some machines before water was entirely off the floor.

In one large metal working plant in this district three large tunnels radiate from the power house, carrying all steam, air, water and power lines to different sections of the plant. One of these tunnels is 16x8 ft. in section and 650 ft. long; another is 10x7 ft. in section and 800 ft. long; and the third is 10x7 ft., 450 ft. long. In all, these tunnels carry thirteen sets of three-phase, 550-volt, rubber-covered feeders in conduit.

In this plant the water rose to a

(Please turn to page 588)

FIG. 9—BRICK WALLS FELL BEFORE THE ONSLAUGHT OF ANGRY WATERS

This is one corner of a basket shop at Becket, Mass.

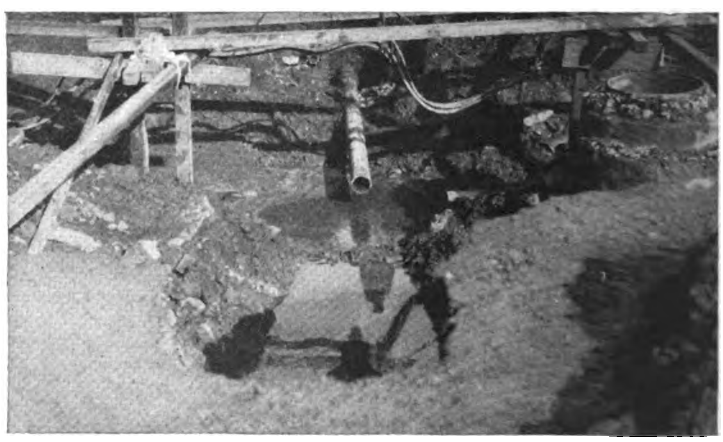
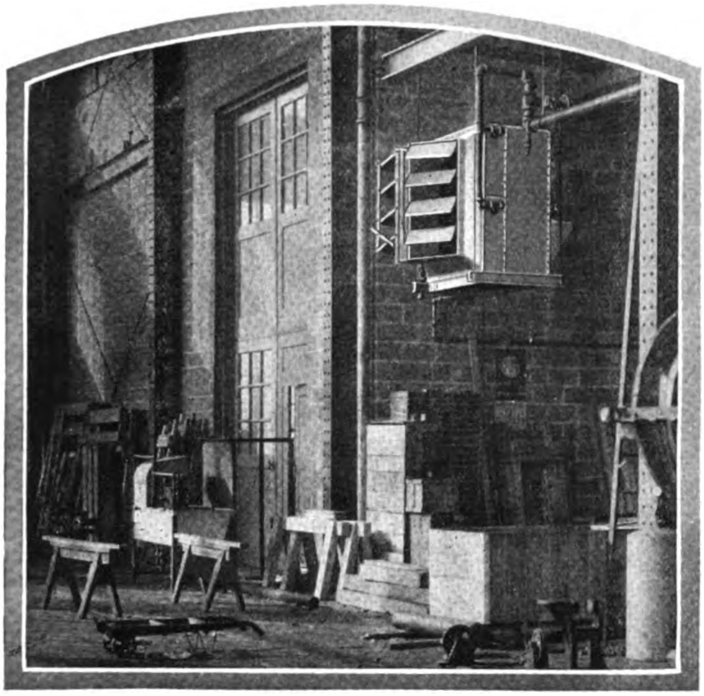


FIG. 10—POWER CABLES AND WATER, GAS, AND SEWER LINES WERE BROKEN WHEN PAVEMENTS WERE WASHED OUT



Suspended-type heaters equipped with deflectors maintain an even temperature in cold corners

How to Determine the Requirements for HEATING The Cold Corner

by C. A. Booth

Vice-President, Buffalo Forge Co. Buffalo, N. Y.

MODERN industrial plants of any size usually are heated with steam, or perhaps with hot water, both very satisfactory mediums, but the age-long struggle to get the best results with the least money often leaves sections which are poorly heated. Either errors are made in estimating the requirements, or unforeseen conditions arise, such as considerably increased glass surface or open shipping doors, so that cold corners result—places where men coming from warmer sections feel the cold severely. It is good business to keep these places comfortable if it can be done without too much trouble and expense, so in this article it is our purpose to show that wherever steam or hot water is available they can be used in an inexpensive way to get first-class results.

The cold corner may be simply a section that has been overlooked, for which no heat was thought necessary for ordinary comfort. In this case, it is a very simple problem. It may be that an unforeseen amount of heat is required on account of opening doors, or because the installation of an exhaust system for the removal of dust, or for ventilation in process work results in removing so much of the room heat that the temperature is lowered below the comfortable working point. In this case, the problem is a little more complicated.

Years ago heating apparatus, like most things in the factory, was installed by the "trial and error" method, which showed some curious results, but the better class of manufacturers and contractors today take into consideration in their heating problems not only the extremes of winter weather temperatures, but the material of which the building walls and roof are constructed, the amount of glass surface, whether it is a one-story building with a high roof or a building consisting of several floors of average height, or whether operating conditions will require a great deal of ventilation with resulting removal of warm air which must be replaced, all of these factors being reduced to a basis of heat units. After this is determined, the capacity of the heating system is specified to provide for the estimated heating requirements, and usually with a sufficient margin to provide for unforeseen conditions that frequently arise.

But how is the heat directed to where it is wanted? Warm air, being lighter than cold air, will naturally rise and diffuse, forming air currents which may equalize temperatures, but this often results in overheating the spaces where heat is not required, for example, under the roof, leaving the floors cold. This is especially noticeable in high buildings, consequently the fan system or mechanical distribution of air has been favored in manufacturing plants for many years, because it made it possible to send the hot air where it is wanted. Now we have the unit heater, a development of the central fan system. It consists of a small individual fan and heating coil, light in weight, requiring either a limited floor space or none at all. It is inexpensive to install, and not dependent on circulation of hot air by gravity, nor on large and unsightly air ducts throughout the plant, but able to supply hot air with about the same accuracy as the charge from a shotgun in the hands of an expert.

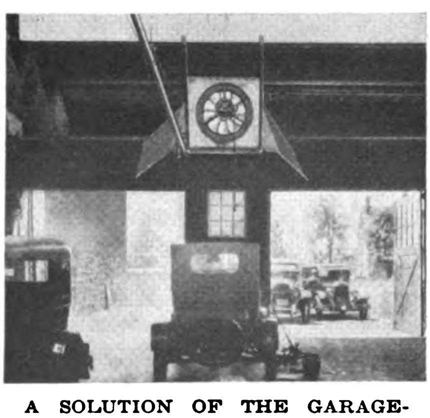
Direct radiation equipment is usually installed along the walls, but for heating large spaces by direct radiation, it is also necessary to either stretch coils overhead, or next to columns. The heated air rises, diffuses and falls again after being cooled, thus setting up currents which tend to raise the room temperature and equalize it but in actual practice are ineffective to the extent that the tendency to diffuse is easily offset by drafts or even by the ordinary chimney effect of cupolas and roof ventilators used in one-story factory buildings. Although types of unit heaters vary in regard to the dis-

tance their influence is felt, it is easily possible to heat uniformly a space which may be from 50 to 150 ft. distant. The air which is set in circulation is many times as great in volume as the actual delivery of the unit heater, as has been shown by the discharge of a smoke bomb in the path of the air discharge. This air acts on the principle of an ejector, creating motion all along the direction of its path, and spreading into distant corners where the eddy currents which are set up finally spend their force.

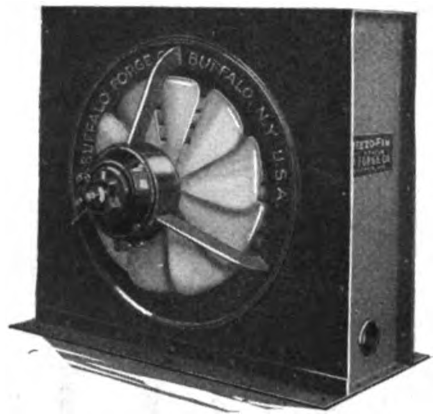
Most of the manufacturers of unit heaters maintain engineering departments for the purpose of making recommendations in specific cases. Nevertheless, it is desirable for the factory manager to know, at least approximately, what can be done, so we intend to mention the points to be considered, and their inherent influence on the selection of unit heaters for a few of the most frequently encountered cases.

As an illustration, let us take a space which is part of a larger building and for which no heat has been provided. The space to be heated is exposed on two sides, only to outside walls.

Normally the determination of the actual heating requirements is based on the heat losses that will take place in the coldest weather, assuming minimum outside temperature and the desired temperature, say 60 deg., inside the building. These losses are ordinarily classified as infiltration or air leakage and losses by transmission or radiation through the various materials of which the building is constructed. Coefficients for heat transmission have been worked out by experiment over a great many years and are available in published form in text books on heating and ventila-



A SOLUTION OF THE GARAGE-HEATING PROBLEM
The Watson Stabilator Co. use a single, suspended unit equipped with large deflectors to direct the warm air toward the open doors.



LIGHT-WEIGHT, SUSPENDED-TYPE HEATER
A Buffalo Breezo-Fin unit heater with brass tube radiators. The extended surface, it is said, provides for a very high rate of condensation.

tion, as well as in engineering handbooks. A few of these constants appear in the accompanying table as shown on page 557.

These constants represent the loss of heat in British thermal units for each degree difference between indoor and outdoor temperatures per square foot of surface. The total transmission loss is thus easily arrived at by selecting the proper constants for wall and roof, multiplying the net area of each after having deducted the area of glass surface, and then adding the heat losses through the windows and skylights by taking the area of each and the proper constant. It will be noted that a corrugated iron roof without sheathing loses heat at five times the rate for a tar and gravel roof laid over matched boards, yet sheathing under the corrugated iron reduces the heat loss nearly two-thirds. A brick wall has the same heat transmission as a tile wall of the same thickness, yet concrete loses heat more rapidly than either. As far as heat transmission is concerned, it will pay in cold climates to use sheathing and building paper, or some type of wallboard.

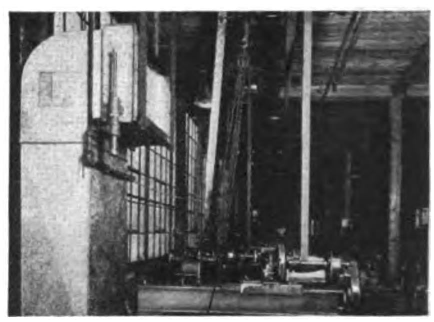
To these transmission losses for the roof and walls must be added the infiltration or leakage which is usually assumed for a factory building of ordinary construction to be from one-half to one and one-half air changes per hour. This means that a volume of outdoor air amounting to from 50 per cent to 150 per cent of the area to be heated will enter through open doors, cracks around windows, etc., and the same amount pass out through roof ventilators or skylights, or by drafts which will carry it into adjoining spaces of the buildings. This outdoor air must then be heated, so the heat thus required must be added to the transmission losses. In a well-built industrial plant of large size, an infiltration of one-half of the cubic content per hour is a fair assumption, but for a cold corner with cold spaces adjoining, however, it will be comparatively safer to figure on one and one-half air changes per hour.

This heat loss equation may be expressed as follows:

$$L = [C\ (T - t)\ 1.5] \div 55.2$$

In this C represents the cubic content to be heated, 1.5 the leakage factor, T and t indoor and outdoor temperatures respectively, and $1 \div 55.2$ which is the specific heat of air, or the number of B.t.u. required to heat one cubic foot of air one degree Fahrenheit.

On the assumption of a total heat requirement of 280,000 B.t.u. per hour for our cold corner, it will be necessary to install a heater of that capacity. Unit heaters are now rated on a guaranteed output in B.t.u., and may be purchased in sizes running from 100,000 to 1,000,000 B.t.u. capacity or over, and whether it may be better in this case to install one large unit or two small ones depends on the shape of the space. If it happens to be long and narrow, two units may be prefer-



FLOOR-MOUNTED, BREEZI-FIN HEATER WITH RECIRCULATING BOX
The cool air enters at the floor level and is drawn through the steam coils, heating the cold corner in the plant of the Excelsior Mfg. Co.

able, but if it is approximately square, a single unit would do just as well.

In most cases it is unnecessary to draw air from outdoors, because sufficient leakage occurs to provide ample ventilation in most factory buildings, and recirculation of air is more economical for this purpose. Suppose two units are selected, each of about 150,000 B.t.u. capacity so as to provide a margin above the theoretical requirements, and which will make it possible to heat the space in mild weather with one unit. These heaters will probably be of the suspended type installed about 8 ft. above the floor so as to provide ample headroom and

placed in such position as to sweep the area to be heated. They will have deflectors so that the air will discharge in a slightly downward direction, and diffuse the air rapidly, so that it will not cause drafts, which are perceptible more than 15 or 20 ft. away, or by the time that the air has reached the working level. If it is a one-story building with a high roof, it may be necessary to use what are commonly known as recirculating boxes on these unit heaters so that the air will be drawn in at the floor line to establish a circuit by which the warm air will be given an increased tendency to confine circulation to the lower levels, instead of overheating the roof spaces. Recirculating boxes are never objectionable unless on account of the floor space they occupy. They are not necessary in industrial buildings having low ceilings.

Coefficients for Heat Transmission

Material for Walls		
Brick	8½ in. thick	0.37
Brick	13 in. thick	0.29
Tile	8 in. thick	0.40
Concrete	8 in. thick	0.60
Concrete	12 in. thick	0.47
Double board (paper between)	1½ in. thick	0.19
Board and corrugated iron	1 in thick	0.36
Corrugated iron siding		1.20
Clapboard, studs, lath and plaster		0.31
Material for Roofs		
Shingles on wood strips		0.87
Shingles on sheathing		0.43
Shingles, paper, and sheathing on strips		0.21
Tar paper on 1-in. roofing boards		0.44
Tar gravel and paper on matched boards		0.30
Slate on 1-in. boards		0.43
Tile and sheathing		0.64
Corrugated iron		1.50
Corrugated iron on sheathing		0.64
4-in. concrete with cinder fill		0.60
Single-glass windows		1.09

Unit heaters in general may be placed to advantage so that they will discharge warm air along the coldest wall, or where the wind exposure is most severely felt. If doors are opened frequently, this is a condition which must be specially provided for by an increased allowance for the cold air. It is quite obvious that direct radiation cannot handle this situation, but the unit heater placed so as to sweep a blanket of warm air across the door will minimize the drafts and sudden changes in temperature which result when large doors are opened in winter. Although no rule can be established to fit all cases, the amount of heat to be provided can be roughly estimated from the area of the door, the assumed velocity of air entering, which will, of course, depend on the exposure and prevailing winds, and the assumed temperature of this amount of air. The unit heater in this case must be large enough to offset this loss.

SUSPENDED-TYPE HEATERS IN THE PLANT OF THE IROQUOIS DOOR CO., BUFFALO, N. Y.

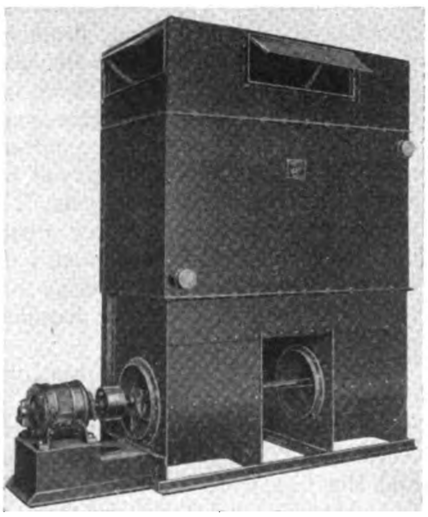
Valuable floor space is conserved for other work, when heaters are mounted overhead as shown. Recirculation is obtained without drafts on the workmen.

Some of the illustrations which accompany this article show actual installations of unit heaters. One of the many advantages is the convenience with which they may be located so as not to interfere with light, with the operation of machinery, with valuable floor space, or with the operation of cranes. There is a single steam supply and return line for each unit and a single valve to open for the proper regulation of the unit.

No precautions are necessary other than to estimate the average or extreme requirements, provide the necessary steam, and carry away the condensation. The small motor driven fans which are furnished as a part of the unit are quiet and efficient. The motors should be entirely inclosed, with waste-packed bearings, so as to require infrequent attention. The suspended units usually have brass tube radiators with an extended surface, giving a very high rate of condensation and a light-weight heater. Two unit heaters of this type, delivering 150,000 B.t.u. each, as in the case we assumed, would weigh about 260 lb. each, complete with fan and motor. The motors would be about ⅓ hp. The heaters would be self-contained, occupying a space approximately 4 ft. long, 30 in. high, and 24 in. deep.

In selecting the units, it must be remembered that the heating capacity must be available with air entering the heater at room temperature; the same unit with air entering from outdoors would have a much greater B.t.u. capacity on account of the increased difference between the steam and air temperatures. A heater which will deliver 150,000 B.t.u. will have its output reduced nearly one-third when air enters from the outside at a temperature of 60 deg. F.

Obviously, the installation of a unit weighing less than 300 lb. is simple. It may be carried on a bracket or supported by hangers from the building structure. The smallest units are often hung from the steam pipe. If recirculating boxes are used they will carry the weight of the heater without requiring any other support. The installation expense is very small, and the results are all that may be desired from the operation. The portability of these units is another advantage, because they can be kept on hand for temporary use and moved from one position to another.



HIGH-PRESSURE STEAM IS NO BAR TO THE USE OF UNIT HEATERS

This Buffalo, floor-type heater is intended to serve the plant having a high-pressure system.

Two Elevator Shafts Plus an IDEA *Equal a* PLAN

in warehouse material handling that has exceeded all expectations

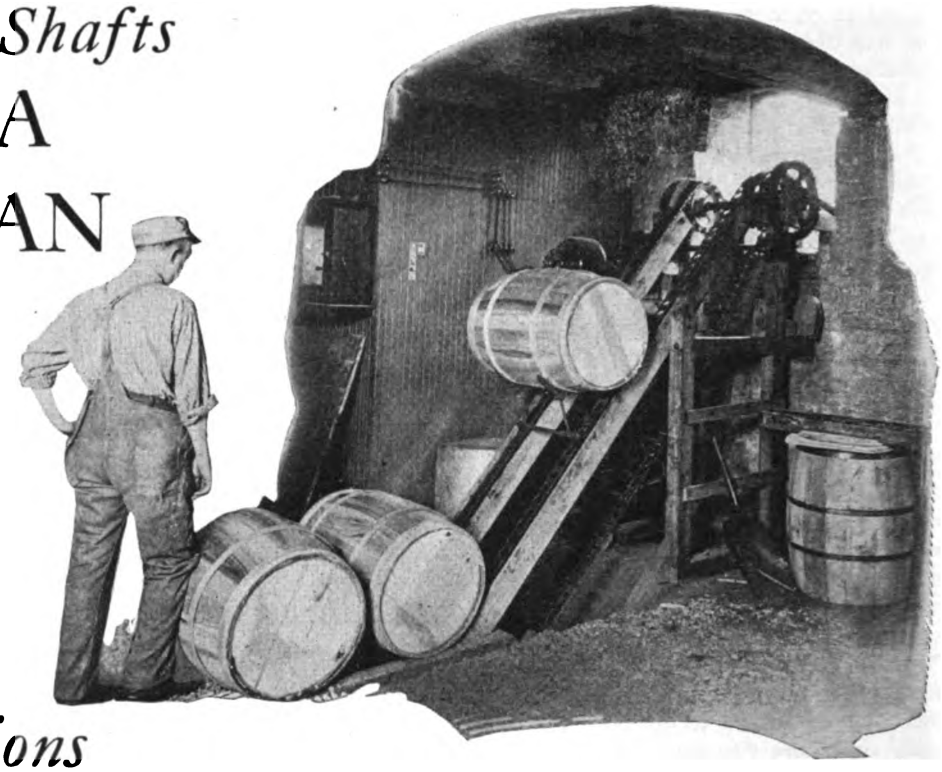


Fig. 1—Suppose you had to lift these 500-lb. barrels of castings from the storage to shipping platform?

EDWARD J. TOURNIER *tells how*

Chain Elevators *Recast Factory Methods*

PROPER correlation of various types of equipment for handling commodities manufactured in quantity is one of the new problems before executives. It is also the basis of the new style factory. There has been in the past a belief that some one class of handling apparatus could serve for a sort of carryall for any kind of manufactured goods. The particular kind of machinery varied in each plant, but there was still the thought that with adaptations one type would solve all of the handling problems.

In a recent instance a platform elevator serving five floors in a warehouse was displaced by a tray elevator. Packing boxes, bags, crates and the like were formerly brought to the various floors and taken away on hand trucks. The tray elevator works automatically, both in loading and unloading, and handles many times as much as the old platform elevator. And had it not been for a timely suggestion, the attempt would have been made to continue hauling goods away from the elevator by the use of hand trucks!

This and other instances will show not only how losses due to scrapped equipment are avoided, but also how combinations of different types of material handling machinery are molding industry in a new form.

The principal factor in the transfer of goods from one floor to another is the direction in which they are to be handled. It needs no explanation, for example, to see that lifting generally costs more than lowering. In the latter case gravity provides the power and in the former case gravity must be overcome by the use of power.

The functions of raising and lowering finished products have necessitated the development of devices for this specific work. These are grouped in two general classifications. The first includes spiral chutes and spiral gravity roller conveyors which are used for lowering only. The second includes chain elevators designed for both elevating and lowering. Elevators intended only for lifting are also classified in the second group.

Chain elevators are subdivided according to whether they are to operate between two floors only, or whether they are to serve a number of floors in both directions. In the first subdivision are the short elevators used to raise barrels, boxes, crates and the like from a basement storage to a workroom above, or to a freight platform.

The term "barrel elevator" is commonly used to describe the short elevators. These machines, as in Fig. 1, usually consist of two strands of chain

connected at intervals by cross rods to prevent spreading of the chains. Arms made of malleable iron or bent steel bars are attached to the chains on whatever longitudinal centers is required to obtain a given capacity for the unit.

The two strands of chain pass over sprockets at the top and bottom of the elevator, and are supported over the intermediate space between shafts by suitable members of timber or steel. The framework of the elevator is usually inclined and the chain guides are provided with flat-steel wearing bars on which the carrying strands of the chain travel. Power is supplied to the head shaft through a spur-gear transmission and a worm-gear speed reducer.

At the loading point, usually at the basement floor or at a point slightly above it, two skids are located in such a manner that the arms attached to the chain pass on the outside. A barrel or other container placed upon the skids will be lifted off by a pair of the moving arms, and on reaching the top of the elevator it will be discharged over the head sprockets as shown in Fig. 2.

Another set of skids at this point receives the package which slides down the incline to its destination. In the case of barrels the slope of the skids is very slight, although for boxes and bags the inclination must be steep. The principal use of such elevators, however, is in elevating barrels or other cylindrical containers. They are used for boxes and bags only where a very low first cost is the first consideration.

At the plant of the U. S. Cast Iron Pipe & Foundry, Burlington, N. J., a barrel elevator of the type described and shown in Fig. 1 is able to handle barrels of small castings weighing about 500 lb. each at the rate of 180 per hour, with only one man in attendance. The barrels are stored in the shipping room, which is slightly below the level of a railroad track adjacent to the building wall, and are delivered direct to the door of a box car. The unloading skids in this case are removable to allow cars to pass close to the wall.

The case just described shows the application of the simplest form of elevator. The service performed, however, cannot be evaluated, except approximately. The former practice had been to roll the barrels on skids into the car by hand labor, usually requiring two men, and in which frequent breakage of barrels was experienced. The elevator, however,

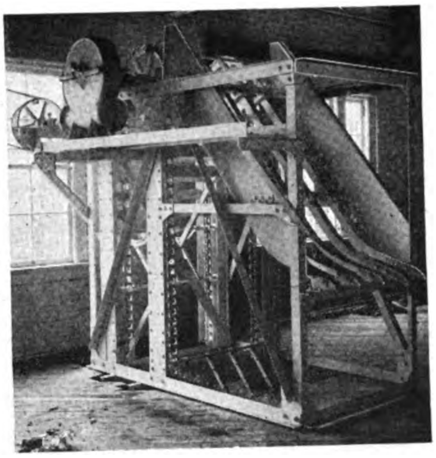


FIG. 2—SAFETY FEATURES ARE INCORPORATED IN THIS INSTALLATION

Note the worm-gear speed reducer application which prevents accidental reversal in the direction of operation. The elevator head is located on the top floor of the building.

reduced the labor to one man and eliminated the breakage.

For many years, a large warehouse in eastern New York, supplying the jobbing trade with practically every class of goods from groceries to gas heaters, handled all of its goods with two platform elevators and hand trucks. The building contains five floors and basement, covering an area about 150 ft. wide and 300 ft. long,

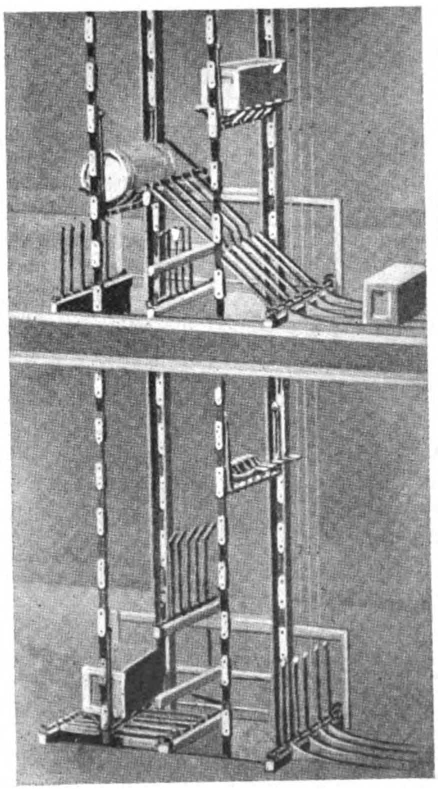


FIG. 3—NO TRAFFIC REGULATIONS HERE

Two way service is maintained with this automatic tray elevator, which also permits loading or unloading on either side.

or approximately 45,000 sq.ft. on each floor. The elevators were located, one at each end of the building, and each had a lifting capacity of 4,000 lb. Five men on each floor unloaded and distributed the boxes, bags, etc., as they were brought up from the lower floors.

A great expansion in the company's business, however, necessitated a reorganization of its handling methods. The platform elevators were inadequate and the distribution was too slow to take care of the movement of commodities to and from the storerooms.

It was then thought that an automatic tray elevator located in the shaft of one of the platform elevators would solve the problem. This, however, would involve scrapping the old elevator and would only partially improve conditions, because it was intended to retain the use of hand trucks. At this point, the warehouse superintendent made the suggestion that it was not necessary to scrap either of the old lifts. The new elevator could be placed centrally in the building, close to the wall, requiring only new openings in the floors. The goods brought up by the elevator could be discharged automatically on to a short apron conveyor, at any floor. They could then be placed on skids which could be taken up by electric lift trucks and distributed wherever needed. On some of the floors, the addition of a tiering machine would complete the system of unloading, distributing and stacking.

Various objections were made to this plan, because it was necessary to lower as well as elevate the merchandise, because the expense would be too great, and because it would require recasting the receiving and shipping facilities, etc. However, the plans were finally adopted, substantially as outlined.

The tray elevator, Fig. 2, which is of the double-strand steel-chain type with cast-iron tray arms, extends from the basement to the fifth floor, a distance of about 70 ft. The trays are spaced 10 ft. apart, which, at a chain speed of 60 f.p.m., gives an hourly capacity of 360 packages weighing 400 lb. each. When fully loaded, the elevator is operated by a 10-hp. electric motor which drives through a worm-gear speed reducer and one spur-gear transmission.

At each floor there is a set of automatic unloading fingers, which are arranged either to load or unload, and which can be placed in position

manually if desired. A short steel apron conveyor with an independent motor drive is used to take the packages away from the elevator quickly. A number of platform skids are kept on hand at every floor near the discharge point of the elevator for this purpose.

These skids are large enough to hold boxes containing an average weight of 500 lb. each. The delivery point of the apron conveyor is arranged so that an elevating platform truck, as in Fig. 4, can receive a load of four of these boxes at one time. The use of two of the elevating trucks permits the almost continuous flow of goods away from the elevator. During the time that one truck is being loaded, the other is distributing its load to the various aisles on the floor.

The installation of this system of handling has required the use of a time schedule for the elevator, and also for the shipping platform, in order to accommodate storage and withdrawal of goods from the different floors. When goods are being shipped direct from the warehouse floors, the operation of the elevator for this particular service cannot be interrupted.

In like manner, storage operations must be continued to completion. As it sometimes happens that emergency shipments must be made when the elevator is in use for storage, a small "balancing" storeroom has been placed adjacent to the shipping platform.

After a year's service of the remodeled system, a number of expected results have been accomplished, and also one at least that was not thought of when the plan was made.

FIG. 5—WHY THE HAND TRUCK?
This is the way goods were handled from an intermediate point on the tray elevator before the platform trucks were adopted.

The installation of the tray elevator, Fig. 5, saved half the wages of one man at each loading and unloading point. The elevating platform trucks permitted the reduction of the labor force on each floor from four men to two, also the time of loading trucks has been reduced 50 per cent with one man less than previously employed.

If the financial side only is considered, it has been found that the savings in direct labor amount to about $8,500 annually; that the upkeep of concrete floors previously worn by truckwheels is eliminated, and that compensation insurance rates are much lower as a direct result.

It had been expected that one of the platform elevators would have to be scrapped, but as previously indicated both were kept. One of them is used for a purpose not thought of at first. During the time that the tray elevator is being used for lowering goods for shipment, only one platform truck, as in Fig. 6, is in service on each floor. The other may be used for other purposes. These spare trucks are placed on the old platform elevator and lowered to the shipping platform level, where they serve in loading motor trucks and for the miscellaneous shifting of goods. The circumstances in this case are unusual of course, as it was merely coincidence that the old elevators had especially large platforms.

All of the facts herein mentioned point to the conclusion that careful planning and co-ordination of suitable equipment produce results impossible by the indiscriminate purchase of even first-class equipment.

For every material handling problem there is a correct solution, and it is for the engineer with specialized knowledge to point out which type of equipment best suits the conditions in the particular industrial plant in which it is to be employed.

FIG. 4—PLATFORM TRUCK IS USED IN DISTRIBUTING GOODS ON THE VARIOUS FLOORS OF THE WAREHOUSE
Unexpected operating economies were obtained from the combination of this type of equipment and the tray elevator.

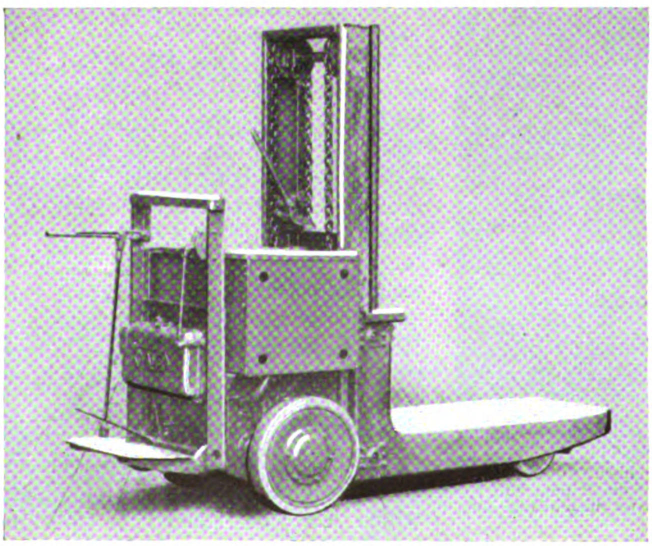


FIG. 6—COMPACTNESS AND UTILITY LEAD TO THE ADOPTION OF THIS TYPE OF PLATFORM TRUCK
Its short wheel base permits the driver to run it on a platform elevator so that it can be used in various parts of the building. All functions are governed from the driver's platform.

In this . . . . . .
the third article
of a series
on the selection
of materials
and the methods
used in building
and repairing
commutators,

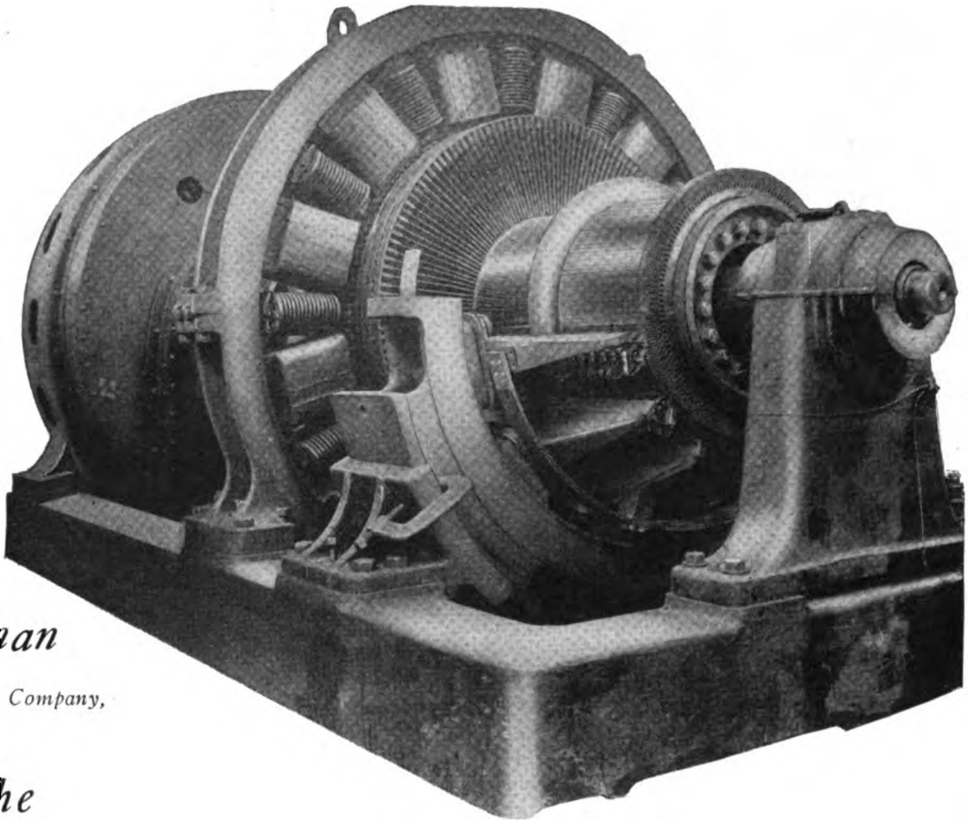


Fig. 1—A ring-bound commutator used for high-speed operation

Jesse M. Zimmerman
Renewal Parts Engineer
Westinghouse Electric & Mfg. Company,
Chicago, Ill.

describes the

Assembly of Commutator Segments

ACCURATE machining to the proper gage diameter is an essential in commutator construction. An explanation, therefore, of gage diameter, and a description of the tool used for measuring this diameter, will not be amiss at this time. The gage diameter of a commutator may be defined as the distance from the point of intersection of the 30 deg. and 3 deg. angles of the copper *V* to the corresponding point diametrically opposite. This is illustrated in Fig. 2 on page 562. Accurate measurement of this dimension can be obtained only with the use of a male bridge gage, as other tools such as scales and calipers do not give satisfactory results.

The accuracy of the gage diameter and the depth of the copper *V*'s are determined, as shown at *A* in Fig. 3, by means of the male bridge gage, which is a special tool made for this purpose. It is used to measure the diameter of the intersecting sides of the copper *V*'s and to check the accuracy of the angles of the *V*'s. This tool has two projections intersecting at two imaginary points which are the same distance apart as the gage diameter to which the copper *V*'s are machined. Since the *V*'s of the assembled segments for *V*-bound and drum-bound commutators are machined to a gage diameter, which is different than the gage diameter of the machined steel *V*'s by a definite predetermined figure, the male bridge gages used in measuring these segments are made different by the same predetermined amount.

The depth to which the *V*'s are to be machined is marked on the projecting *V*'s by a special tool as illustrated at *B* in Fig. 3. This tool is so made that it will fit over the end of the projecting *V* having a clamp which holds a steel scale. The extended 30 deg. and 3 deg. sides of the *V* of this tool have an intersecting point, which corresponds to the intersecting point of the sides of the copper *V*. For example, assume that the *V* is to be machined 2 in. deep. Then the 2-in. point of the steel scale is matched with the intersecting point of the *V* on the tool. The tool fits over each projecting *V* of the male bridge gage. The depth to which the *V* is to be machined is designated by the end of the steel scale. These points being marked on the side of each projecting *V* of the male bridge gage will be in alignment with the end of the bar as shown at *A* and *B* in Fig. 4, when the correct machined depth of the *V*'s has been obtained.

Since there are three different types of commutator construction used on d.c. industrial motors, there are three different methods of preparing the assembled copper bars and mica strips for use in these commutators. The three types of commutator construction are:

(*1*) Arch-bound.
(*2*) V-bound.
(*3*) Drum-bound.
  (*a*) Standard construction.
  (*b*) Shrink-ring construction.

In an arch-bound commutator, the copper bars and mica strips form an arch. The steel *V*'s of the bush-

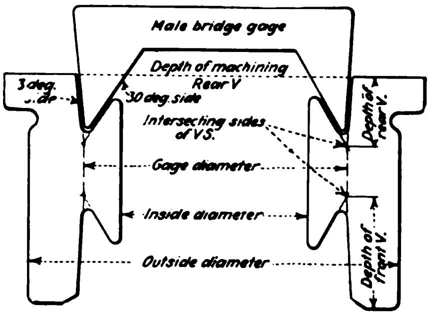


FIG. 2—MALE BRIDGE FOR GAGING COMMUTATORS

This tool has two projections intersecting at two imaginary points which are the same distance apart as the gage diameter to which the copper V's are machined.

ing, as indicated at *A* in Fig. 5, exert a radial force directly on the 30 deg. angle of the *V*'s of the copper bars and mica strips until they arch bind. This places the mica strips under a constant pressure when the commutator is tight.

Earlier commutators were of this type and it was necessary to tighten the commutator and re-turn the surface at the slightest indication of high bars. High bars were due to the whole structure loosening during the so-called process of seasoning, when the bond in the mica strips squeezed out, or if any shrinkage of the mica should be prevalent. This led to the development of the *V*-bound commutator.

After extensive tests, it was found that by machining the gage diameter of the *V*'s of assembled segments to a definite predetermined amount, which is dependent upon the size of the commutator, different than the gage diameter of the steel *V*-ring, it was possible to eliminate the difficulty encountered with high bars on the arch-bound commutators. When the commutator is assembled, the pressure of the mica *V*-ring is first exerted on the 3 deg. angle of the copper *V*. When the banding wire is cut, the bars will all push outward, thus sufficiently relieving the arch-bound pressure between the copper bars and mica strips so that each bar will be held firm by the *V*-ring. When assembling cold, opened-up places will appear after the banding wire is cut. This is how the name "opened-up" commutator was applied.

After the assembled commutator has been heated and a pressure applied to the steel *V*-ring, the pressure is also applied to the 30 deg. angle of the copper *V*, thus drawing the bars in. When the assembly is cold, pressure will be applied on the 30 deg. as well as the 3 deg. angle, as indicated at *B* in Fig. 5, thus holding each individual bar firmly so that it cannot rise or lower, should the bond squeeze out or the mica strips shrink. This can be proved by disassembling a commutator, and noting that both the 3 deg. and 30 deg. angles of the bar are seated firmly in the mica ring.

The drum-bound standard construction is used mostly on large commutators of the large reversing motors and power generating apparatus found in the average industrial plant. Commutators of this type are assembled by having the bars forced in radially until they bind on the bushing. In order to obtain this condition, it is necessary to machine the bore and the gage diameter of the *V*'s a definite predetermined amount, which is dependent on the gage diameter of the commutator, different than the gage diameter of the steel *V*'s. When the segments are assembled on the bushing, the pressure on the mica between the bars, as shown at *C* in Fig. 5, will be relieved sufficiently to permit the bars to be drawn in by a radial pressure so that the bars will bind on the bushing.

With the drum-bound shrink-ring construction it is necessary to provide an additional means of sustaining the bars on commutators having a long brush face which must be operated at high speeds. This is accomplished by shrinking a metal ring over the copper segments, as may be noted in Fig. 1. The commutator is assembled and seasoned in the same manner as the drum-bound commutator. After the commutator has been properly seasoned, one or more metal rings are shrunk over the commutator face. The number of rings is dependent on the length of the commutator face and the peripheral speed of the commutator.

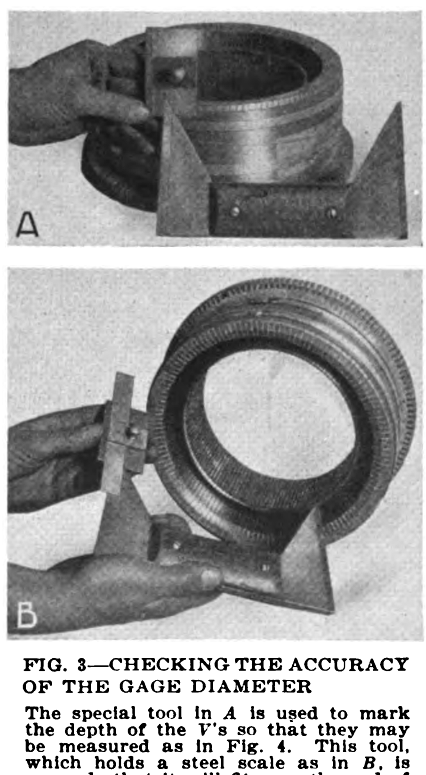


FIG. 3—CHECKING THE ACCURACY OF THE GAGE DIAMETER

The special tool in *A* is used to mark the depth of the *V*'s so that they may be measured as in Fig. 4. This tool, which holds a steel scale as in *B*, is so made that it will fit over the end of the projecting *V*.

If no mica extension is desired, the building is done on a flat surface, as shown in Fig. 6. After the mica strips and copper bars are built on a building plate, they are assembled on a dummy bushing. The assembled segments are then placed in an oven and heated to 150 deg. C. A split ring, having a tapered face on the outside, is placed around the assembled segments while they are hot. A strip of fishpaper is placed between the ring and the assembled segments. A solid ring, which has a reversed tapered face on the inside, as in Fig. 7, is placed over the split ring and pressed on at a pressure of from 20 to 30 tons. This produces an arch-bound assembly. The dummy bushing is then removed and the commutator is allowed to cool before the *V*'s are machined.

As soon as the rectangular copper bars and mica strips are built up, a three-piece clamp ring, as shown in Fig. 7, is placed around them and the bolts are drawn tight, a strip of fishpaper being placed between the ring and the assembled segments. It is important that the assembled segments form as true a circle as possible. After the clamping ring is tightened around the assembled segments, they are placed in an oven and heated at 150 deg. C. The bolts on the clamping ring are then pulled tight, forming an arch-bound assembly.

On large diameter commutators, it is necessary to use a solid ring with set screws and segmental blocks for clamping the segments. The segmental blocks, as illustrated in Fig. 8, span two set screws and are cut beveled so that they overlap, thus applying a pressure to every bar.

In the manufacture of a set of assembled segments there are certain refinements which are essential, if the life and service are expected to equal those of the original commutator. The lack of these refinements often causes unnecessary commutator failures. Every commutator failure invariably means damaged armature coils and various other troubles which will cause delays in service so that one must take into consideration the cost of the delays caused by a commutator failure when

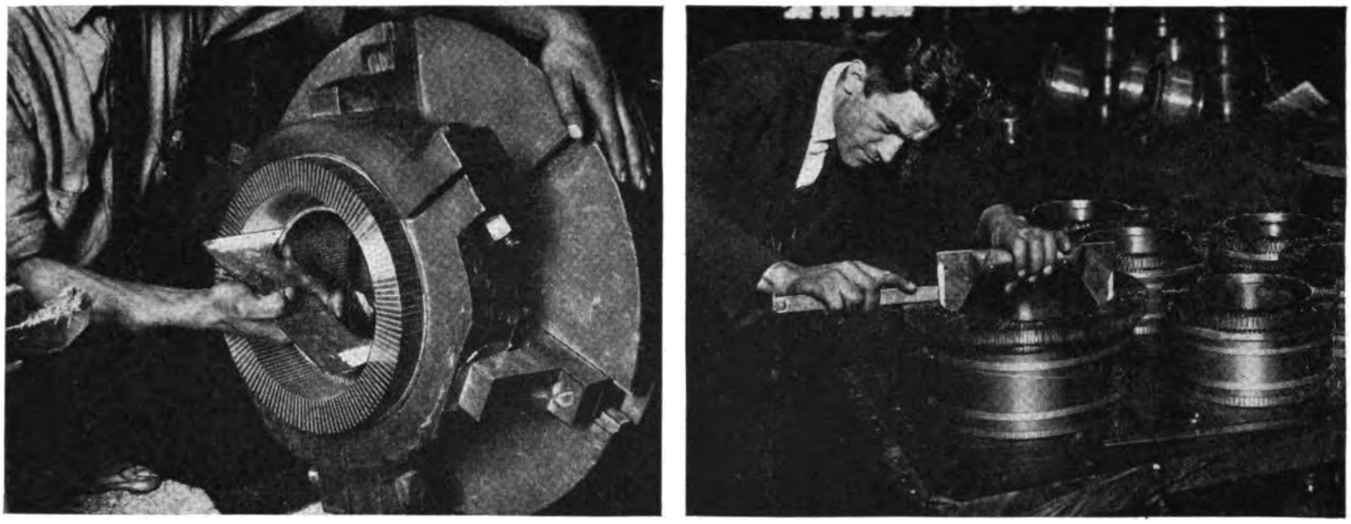


FIG. 4—A SPECIAL MALE BRIDGE GAGE USED IN CHECKING ASSEMBLED SEGMENTS

The machined *V* in the set of assembled segments is checked during the machining operation as in *A* at left. Final checks are made as in *B* at right, when the correct machined depth of the *V*'s has been obtained.

specifying renewal commutators. Some of the refinements necessary in the manufacture of assembled commutator segments are as follows:

(1) The copper bars and mica strips should meet the requirements outlined in parts *I* and *II* of this series of articles.

(2a) A rear mica extension of $\frac{1}{16}$ in. should be allowed on all 500-volt commutators when possible. It serves as a barrier between the bars, thus eliminating the possibility of short circuits caused by solder while soldering the armature leads. It also increases the creepage distance between bars at this point.

(2b) A mica extension of $\frac{1}{32}$ in. is desirable in the bore of the assembled commutator segment. This mica extension, along with a $\frac{1}{32}$-in. radius at the bottom chord of the bar, provides ample creepage distance between bars. Sometimes the distance between the commutator spider and the bore of the assembled segments is so small that it is necessary to machine the bore in order to provide sufficient clearance to assemble the mica *V*-ring and mica bushing. When the bore is machined, the burr, which is dragged to one side of the bar by the machine tool, should be removed by a special engraving tool being drawn over the mica strip. This tool gives the bar a small radius as well as removing all copper "drag overs," thus increasing the creepage distance between bars.

(3a) The commutator bars should not be out of axial alignment more than the width of a mica strip. It is essential that the bars be parallel with the carbon so that the brush will short-circuit the same bars at the front of the commutator as at the rear.

(3b) The distance from any bar to the corresponding bar under the next pole should not vary more than plus or minus $\frac{1}{32}$ in. This variation is controlled by keeping the variation of the copper bars and mica strips within the specified variation of plus or minus 0.001 in. If this variation is larger or smaller, sparking may be prevalent at these spots. This is equivalent to increasing or decreasing the width of the commutating zone while the brush setting remains constant. Consequently, when a wider or narrower commutating zone passes under the brushes, they must short-circuit bars connected to coils whose potential is not zero. Therefore, sparking may be prevalent at these points.

(4a) Assembled segments should be heated to a temperature of from 125 deg. to 150 deg. C., in an automatic temperature controlled oven before the *V*'s are machined.

(4b) The process of heating the assembled commutator segments before the *V*'s are machined is neither to drive out the moisture, nor to get rid of the excess bond, as the mica plate should not contain live bond which will squeeze out. They are heated above the maximum temperature to which they will be subjected in service, so that the bond in the mica, which is hard when it is cold, will soften and conform or adjust itself to the irregularities of the bars. This permits the clamping ring to draw the individual bars into a tight arch-bound assembly under maximum temperature conditions to which it will be subjected in service. It is this adjusting quality of mica which makes

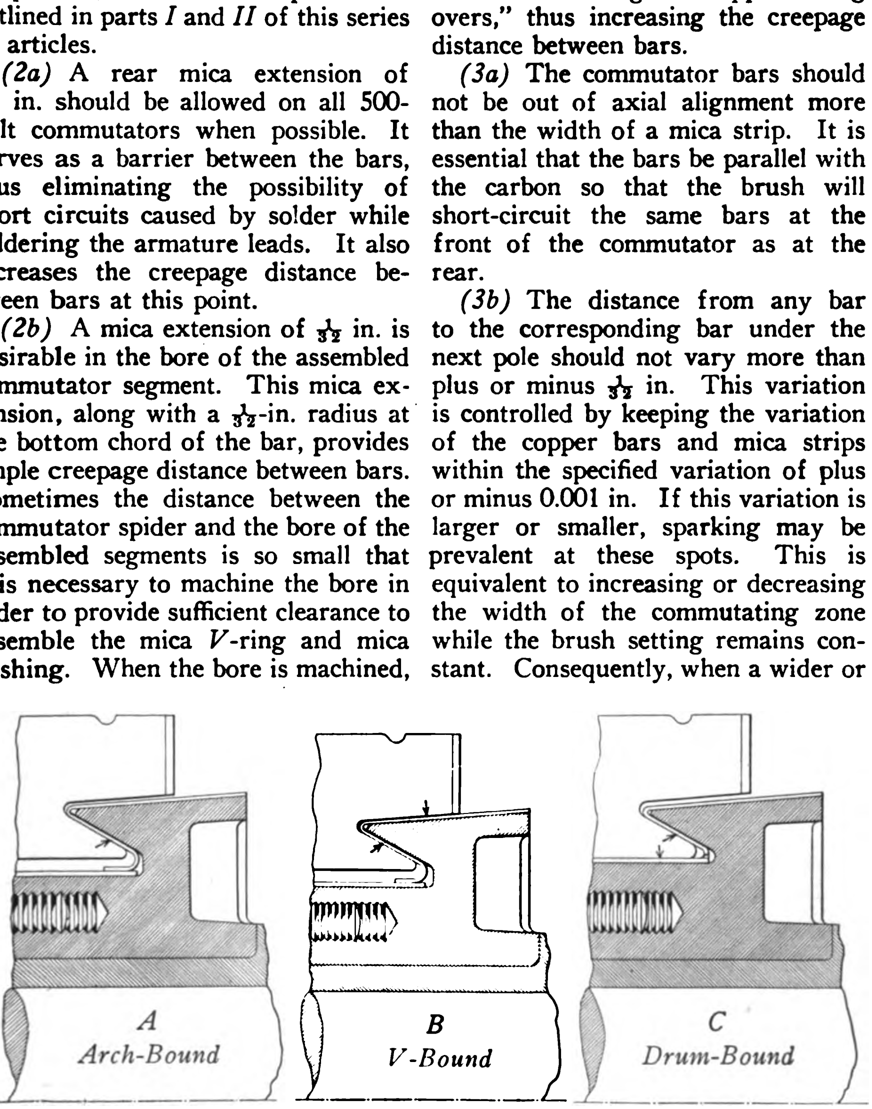


FIG. 5—PRESSURE DISTRIBUTION IN THE THREE TYPES OF COMMUTATORS

In *A*, the steel *V*'s of the spider and metal *V*-ring exert a radial force directly on the 30 deg. angle of the assembled segment. In *B*, the pressure is applied to both the 3 deg. and 30 deg. angles, thus holding each individual bar firm. In *C*, the pressure of the metal *V*'s of the spider and *V*-ring exerts a radial force on the 30 deg. angle of the copper *V* until the bore of the assembled segments binds on the body of the bushing. The mica strips are under sufficient pressure to keep out oil and moisture. The points of pressure are indicated by the arrows.

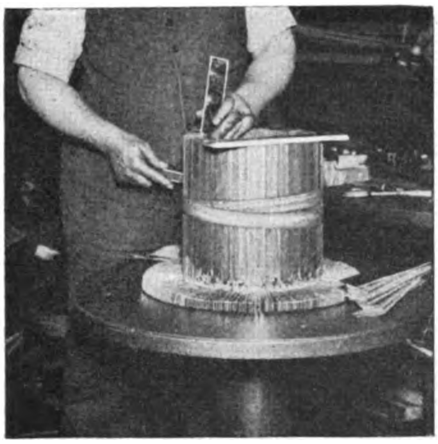


FIG. 6—BUILDING OPERATION ON A FLAT PLATE

When no mica extension is used the mica strips and copper bars are assembled on a dummy bushing.

the breathing action of a commutator possible when it passes through the alternate heating and cooling periods in operation. The use of the mica plate, which does not have the bond seasoned, should be avoided for use as commutator strips, as the bond will squeeze out.

(4c) Heating softens the surface shellac, thus cementing the copper bars and mica strips into a solid body and facilitating assembling when the banding wire is cut. This cementing action of the surface shellac on the mica strips also keeps the oil and moisture absorption at a minimum.

(5a) The *V*'s of the assembled segments must be machined with a machine tool held in a positive slide set for each angle. This insures that the 30 deg. and 3 deg. angles will always be symmetrical with the gage line, insuring absolute interchangeability and a tight fitting job when the commutator is assembled. If the angles are not symmetrical, the designated 30 deg. angle may be 29 deg., thus making the designated 3 deg. angle 4 deg. It can be seen that, with this condition, a space will be left between the 3 deg. angle of the copper and the mica *V*-ring. When this happens, it is necessary to remove the *V*-ring and build it up so as to make the commutator tight at this point, thus keeping the oil out.

(5b) The gage diameter of the assembled segments must be machined so as to relieve the arch-bound pressure between the bars sufficiently to produce the *V*-bound and drum-bound types of construction. This has been discussed in the preceding part of the article.

(5c) The machined *V*'s must be gaged with a permanent male bridge gage while they are held by the steel clamping ring. The use of this gage has been discussed in a preceding paragraph.

(5d) The 3 deg. angle of the assembled segments must be machined so that it will form a tight joint between the copper bars and the mica *V*-ring, thus keeping the oil and moisture from penetrating the commutator.

(6) All burrs and copper drag overs from the machining operation in the *V*'s must be removed by running an engraving tool over the mica strip between the bars in the *V*'s.

(7) The machined *V*'s should be painted with a coat of thin shellac. This protects the *V*'s from dirt, oil and moisture while in storage.

(8) The milled slots for the conductors in the solid-neck commutators should have the bottom corner at the rear of the slot rounded. If a sharp edge is allowed to remain at this point, it may cause a nick in the armature coil lead, thereby increasing the possibility of broken leads.

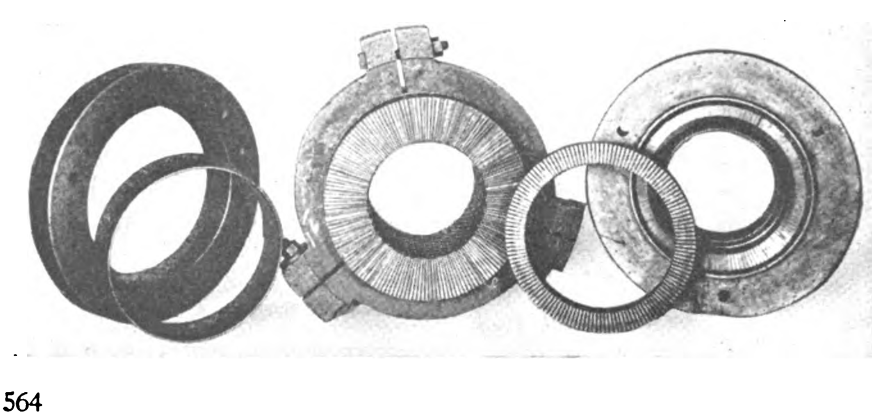
(9) The milled slots should be coated with pure resin flux to eliminate corrosion and to facilitate the soldering of the leads when winding the armature.

(10) Where the assembled segments are to be used with a two-piece mica *V*-ring, a duct must be machined in the bottom of the *V*'s for the clearance of the mica *V*-ring.

(11) A 500-volt bar to bar test should be made to show up any possible short circuits.

FIG. 7—TWO METHODS OF CLAMPING ASSEMBLED SEGMENTS

As soon as the rectangular copper bars and mica strips are built up, a solid ring is pressed on, or a three-piece clamp ring is placed around them and the bolts drawn tight.



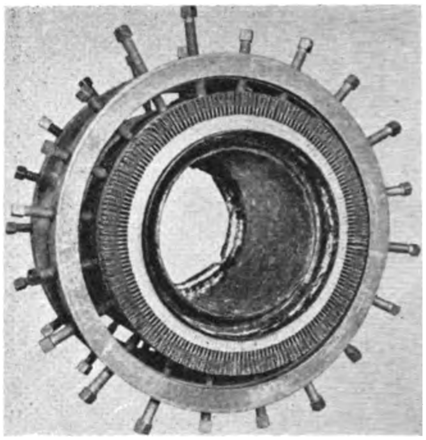


FIG. 8—SOLID CLAMP RING USED ON LARGE DIAMETER COMMUTATORS

The segmental blocks span two set screws and are cut beveled so that they overlap, thus applying a pressure to every bar.

Polarity Tests for Series, Shunt and Interpole Field Connections

VARIOUS tests are in use for determining the polarity of series, shunt and interpole fields in a direct current machine in order to check if they are properly connected in the circuit. In putting a compound-wound machine in service, it is frequently necessary to check the action of the series and shunt fields separately, that is, determine whether they assist or buck one another. In the case of a motor, or even a generator where a suitable power supply is available, a commonly used test is to disconnect the shunt field and connect the machine to the line for just long enough to determine the direction of rotation. If the series and shunt fields assist one another, then the direction of rotation should be the same whether the shunt field is disconnected or not. In the case of a compound-wound motor, which is virtually a series motor with only a very light shunt winding for stability, this test should be made with each field winding separately in circuit.

In an interpole machine, the armature and interpole windings must always be considered as one winding when making any changes.

Madison, N. J. C. D. VAN ANDEN.

Efficiency, smooth operation, and low maintenance cost can be achieved only by regular and thorough inspection and lubrication of equipment

J. F. MORGAN *tells how*

Scheduled Oiling

Prevents Motor Trouble

SEVERAL years ago, after experiencing considerable trouble and delays because of motor bearing failures, we concluded that our motors were not being oiled and cleaned regularly and often enough. The oiling and cleaning of all motors was done by a man outside of the control of the electric department, which had no jurisdiction as to the amount of time this oiler should spend on the motors. However, he was "supposed" to give all necessary attention to the motor bearings.

In order to prove our contention that insufficient attention was being given to the motors, we had a number of cards printed which carried the numbers of all the motors. The oiler was asked to check off the numbers of the motors as he oiled and cleaned them. This plan was tried for about a month. The cards showed that one motor, in the cafeteria kitchen, was visited daily, while a number of others had not been touched.

We then put into effect a schedule of oiling which provided for a regular examination once every two weeks of each motor under the oiler's care. Since this plan has been inaugurated, our motors have been giving better service. We feel that the system is satisfactory for our class of work, which is the manufacturing of hosiery and underwear from wool, cotton, silk and rayon.

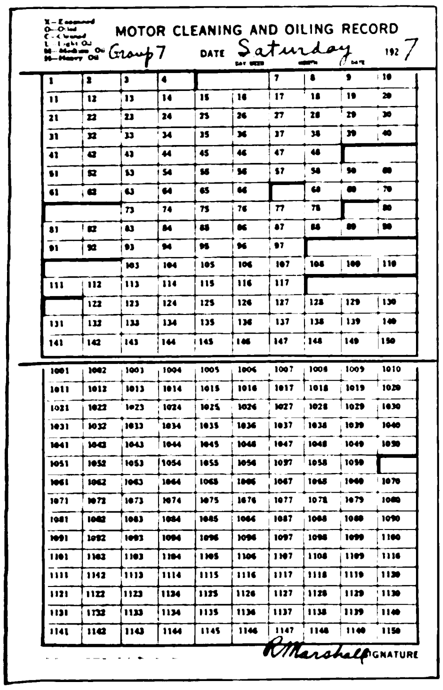
Of the 231 motors of various sizes in the plant the oiler takes care of 159, which includes all the larger motors and some of the smaller ones. The remaining 72 motors are oiled by members of the several departments in which the motors are located. One department with 57 small motors uses the "Oiling" cards, checking off the numbers of each motor as serviced, and afterwards the cards are sent to the electrical department. This oiling is done on or about the first and fifteenth of each month.

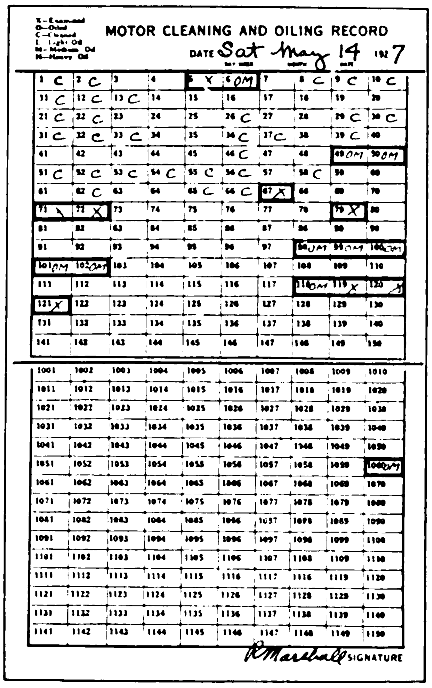
When forming the schedule of oiling for the oiler, the 159 motors were listed under 12 groups and each group given a schedule number for reference purposes. The numbers chosen for these groups were 2 to 7 and 9 to 14, inclusive; these numbers corresponded to the 12 working days in a period of two weeks.

The arrangement or grouping of the various departments and the method of assignment or scheduling to the various days of the two-week period is indicated in Table I. In two cases two of the smaller departments are handled in a day.

A list of oiling dates for the year was prepared, Table II, using the first Monday in the year (Jan. 3, in 1927) as the starting point. This became the first date of Group or Index 2; the next day became the first date of Group 3, and so on. Each group of motors has servicing dates recurring each two weeks, as indicated on the index schedule, Table II. This gives each group of motors 25 or 26 oiling dates during the year.

To simplify the marking of the daily cards, which are given to the oiler, 12 stencils were cut out of "daily cards." Each stencil was made by cutting out the numbers of





FIGS. 1 AND 2—THE STENCIL AT LEFT IS USED TO MARK CARD AT RIGHT

This stencil is for group 7, and is used on the dates indicated under No. 7 in Table II. Rectangles are drawn with red crayon by using the stencil on the oiler's card. The servicing given each motor is indicated by symbols placed alongside the motor number.

Table I—Grouped Departments for Oiling

Departments	Index No.	Day of Week
Worsted	2	Monday
Picker building	3	Tuesday
Mechanical	4	Wednesday
Stores and basement	4	Wednesday
General and office	5	Thursday
Underwear drying	6	Friday
Dyehouse	7	Saturday
Hosiery knitting	9	Monday
Underwear knitting	9	Monday
Winding, sewing, boxing	10	Tuesday
Underwear sewing, boxing	11	Wednesday
Hosiery boarding, boxing	12	Thursday
Spinning and carding	13	Friday
Carding	14	Saturday

TABLE II—OILING DATES, 1927 INDEX

GROUP	No.2	No.3	No.4	No.5	No.6	No.7	No.9	No.10	No.11	No.12	No.13	No.14
Jan.	3,17,31	4,18	5,19	6,20	7,21	8,22	10,24	11,25	12,26	13,27	14,28	1,15,29
Feb.	14,28	1,15	2,16	3,17	4,18	5,19	7,21	8,22	9,23	10,24	11,25	12,26
Mar.	14,28	1,15	2,16	3,17	4,18	5,19	7,21	8,22	9,23	10,24	11,25	12,26
Apr.	11,25	12,26	13,27	14,28	1,15,29	2,16,30	4,18	5,19	6,20	7,21	8,22	9,23
May	9,23	10,24	11,25	12,26	13,27	14,28	2,16,30	3,17,31	4,18	5,19	6,20	7,21
June	6,20	7,21	8,22	9,23	10,24	11,25	13,27	14,28	1,15,29	2,16,30	3,17	4,18
July	4,18	5,19	6,20	7,21	8,22	9,23	11,25	12,26	13,27	14,26	1,15,29	2,16,30
Aug.	1,15,29	2,16,30	3,17,31	4,18	5,19	6,20	8,22	9,23	10,24	11,25	12,26	13,27
Sept.	12,26	13,27	14,28	1,15,29	2,16,30	3,17	5,19	6,20	7,21	8,22	9,23	10,24
Oct.	10,24	11,25	12,26	13,27	14,28	1,15,29	3,17,31	4,18	5,19	6,20	7,21	8,22
Nov.	7,21	8,22	9,23	10,24	11,25	12,26	14,28	1,15,29	2,16,30	3,17	4,18	5,19
Dec.	5,19	6,20	7,21	8,22	9,23	10,24	12,26	13,27	14,28	1,15,29	2,16,30	3,17,31

all the motors in each group. The stencil for Group 7, Fig. 1, indicates the motors to be oiled in the dyehouse every other Saturday.

A month's supply of daily cards is usually prepared at a time. This is done by first marking the date on each card, and then using the different stencils in rotation. Rectangular enclosures are marked with a colored pencil around the numbers of the motors to be oiled.

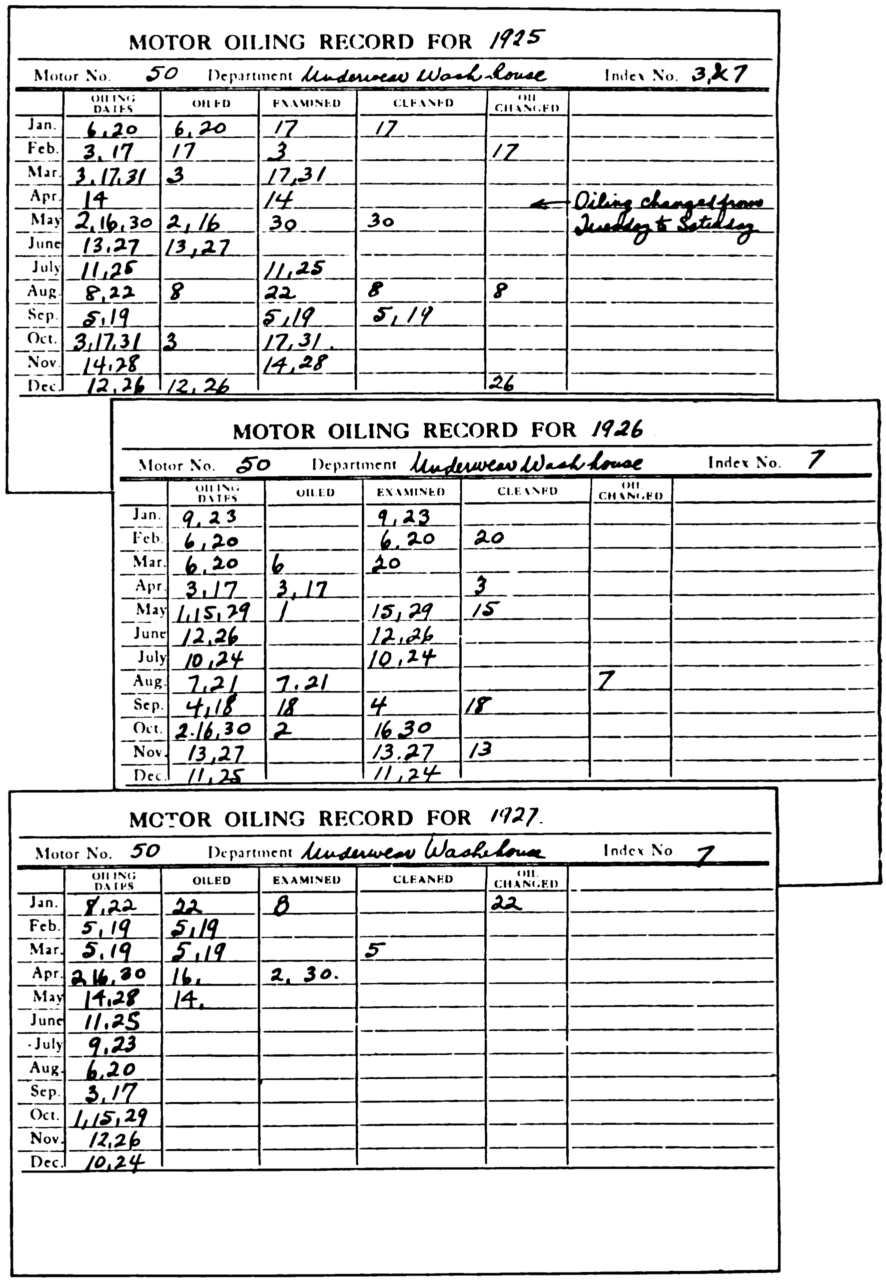
Fig. 2 shows a card which has been marked up from the stencil, Fig. 1, for Saturday, May 14, 1927, and the notations which have been made on the card by the oiler. When motors are added to or removed from the different departments, the stencils are changed or new ones cut. With the aid of the stencils 25 to 30 cards can be marked, ready for the oiler, in a few minutes.

The oiler marks, on the daily card, Fig. 2, the symbols showing what he did to each motor visited, and the cards are returned to the electrical department, where the information is transferred to yearly cards. Fig. 3 is the yearly card for motor No. 50. These cards show when the oil was last changed, or the motor cleaned, and indicate if a motor is requiring more than the usual attention.

Oiling oftener than usual usually indicates worn bearings or other defects requiring specific attention. Sometimes, of course, a motor may require attention in between regular oiling dates, as when a belt is tightened. The large number of "C's" (cleaned) on Fig. 3 indicates that the operator took advantage of the Saturday to clean a number of the motors which could not be handled during the week.

The oiler finds the cards are of considerable assistance to him, because each day's allotment of motors is plainly indicated. He knows, too, that he will not miss any motors on account of poor memory, as sometimes happens if memory alone is depended upon to remember motors in out-of-the-way places.

We have tried this method for over two years, and while it may appear to necessitate considerable work, we have found after the cards are once put in use, very little work is required to keep the records up to date. With an occasional checking of different motors by another man, we feel confident that the motors are receiving regular attention.



MOTOR OILING RECORD FOR 1925

Motor No. 50 Department Underwear Wash house Index No. 3 & 7

	OILING DATES	OILED	EXAMINED	CLEANED	OIL CHANGED	
Jan.	6,20	6,20	17	17		
Feb.	3,17	17	3		17	
Mar.	3,17,31	3	17,31			
Apr.	14		14			← Oiling changed from
May	2,16,30	2,16	30	30		Tuesday to Saturday
June	13,27	13,27				
July	11,25		11,25			
Aug.	8,22	8	22	8	8	
Sep.	5,19		5,19	5,19		
Oct.	3,17,31	3	17,31.			
Nov.	14,28		14,28			
Dec.	12,26	12,26			26	

MOTOR OILING RECORD FOR 1926

Motor No. 50 Department Underwear Wash house Index No. 7

	OILING DATES	OILED	EXAMINED	CLEANED	OIL CHANGED	
Jan.	9,23		9,23			
Feb.	6,20		6,20	20		
Mar.	6,20	6	20			
Apr.	3,17	3,17		3		
May	1,15,29	1	15,29	15		
June	12,26		12,26			
July	10,24		10,24			
Aug.	7,21	7,21			7	
Sep.	4,18	18	4	18		
Oct.	2,16,30	2	16,30			
Nov.	13,27		13,27	13		
Dec.	11,25		11,24			

MOTOR OILING RECORD FOR 1927.

Motor No. 50 Department Underwear Washhouse Index No. 7

	OILING DATES	OILED	EXAMINED	CLEANED	OIL CHANGED	
Jan.	8,22	22	8		22	
Feb.	5,19	5,19				
Mar.	5,19	5,19		5		
Apr.	2,16,30	16.	2, 30.			
May	14,28	14.				
June	11,25					
July	9,23					
Aug.	6,20					
Sep.	3,17					
Oct.	1,15,29					
Nov.	12,26					
Dec.	10,24					

FIG. 3—EACH MOTOR HAS A SIMILAR RECORD CARD

The data from Fig. 2, the daily report, are entered on these individual record cards so that the complete history of all servicing of any motor is available for reference at any time. At the end of the year this card is filed. The cards for 1925, 1926, and 1927 give a complete history of the attention received by this motor.

Operating Furnace Doors Electrically

How it was done is told

by

E. G. Peterson

Electrical Engineer, The Cutler-Hammer Mfg. Company, Milwaukee, Wis.

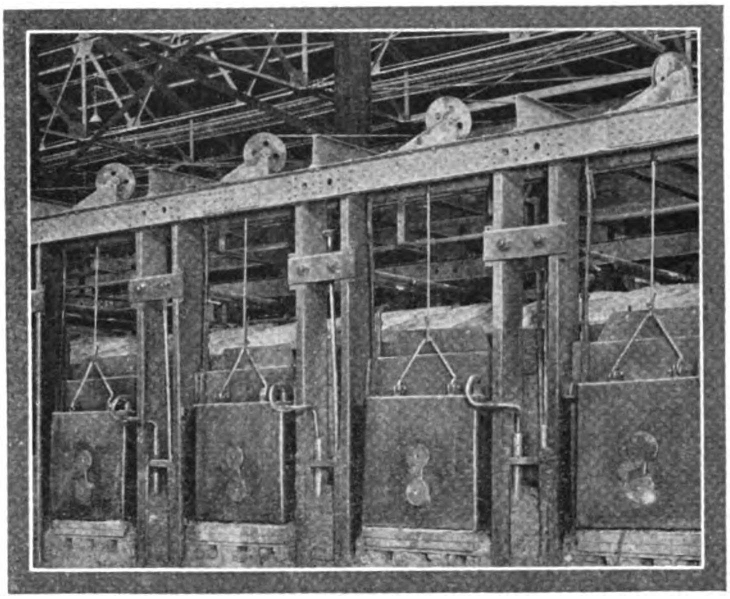


Fig. 1—A front view of the electrically operated furnace doors

THE furnace doors were operated by a "pull-up-boy" whose only duty was to stay at his post and operate the control valves when the heater told him to do so. The elimination of this "pull-up-boy" has resulted in a saving of about $1,500 a year.

IN THE early days of making steel the steam engine and the hydraulic cylinder were the two most common sources of power. The steam engine was used to drive such auxiliaries as roll tables on which the power from a rotating engine shaft could readily be used through a simple gear drive. The hydraulic cylinder was used on those auxiliaries requiring a reciprocating motion, such as screw downs, manipulators, shears, soaking pit covers, and open hearth furnace doors.

With the increased application of electric power, the electric motor rapidly supplanted the steam engine, not only because of the many advantages in the transmission and application of electric power, but also because it removed many of the troublesome mechanical difficulties involved in connection with the steam drive. The change over was easily made, in that, generally, it was only necessary to supply the proper pinion on the motor shaft and set the motor in the place occupied by the engine.

The application of the electric motor, with its power available at the periphery of a shaft rotating at high speed, to auxiliaries having a slow, reciprocating motion was more difficult. However, steel mill designers have found various solutions. For example, an electric motor operates the screw down through a revolving nut and threaded screw. Manipulators are operated by an electric motor through a crank drive, soaking pit covers through a rack and pinion, and open hearth furnace doors through a cable attached to a rotating crank arm.

The front of a modern open hearth furnace with the doors arranged for electrical operation and control is illustrated in Fig. 1. Each door is kept in position by guides and is raised and lowered by a single cable attached to a bail and passing over idler pulleys to a small revolving crank driven by a 230-volt, d.c. series-wound, type K3 Westinghouse motor. The five motor-driven cranks, one for each door, are grouped at the rear of the furnace, as shown in Fig. 2. These cranks are driven through a special speed reducer of the worm-gear type with a single spur-gear reduction between the motor and the worm shaft. A type KT, C-H electric disk brake on the motor shaft holds the door safely at any desired open position and prevents slack cable due to motor drift.

The control is of the simplest kind consisting of a dustproof, rugged 9460 type J-2 Cutler-Hammer drum controller designed for reversing service. To open the door the controller handle is moved in one direction and to close the door the controller handle is moved in the opposite direction. Normally, the operator watches the door and returns the handle to the "off" position when the door is opened or closed the proper amount. Limit switches are unnecessary since the only thing that can happen, if the operator leaves the handle in the "run" position, is to have the door open to its maximum opening and then start to close as the crank continues to rotate. The length of this crank arm is such that the door is moved from "open" to "closed" by rotating the crank arm through 180 deg. Continued rotation merely closes the door.

For the sake of convenience and to provide an unobstructed floor space the drum controllers are mounted in an inverted position on a skeleton framework, as shown in Fig. 3. By so doing it has been possible to install them at the edge of the charging floor where they are readily accessible

and can be operated by the "heaters" while watching the doors.

Previous to the use of electric power to operate these furnace doors, hydraulic power was used. The control valves require so much floor space that it was necessary to locate them at some distance from the charging floor. They were operated by a "pull-up-boy" whose only duty was to stay at his post and operate the control valves when the "heater" signalled him to do so. The elimination of this "pull-up-boy" has resulted in a saving of approximately $1,500 a year. The total cost of the complete electrical installation, including hoists, motors, brakes, and controls, was approximately $3,500. It is self evident that the installation will pay for itself in two or three years from this saving.

In cold weather the pipe lines would freeze unless precautions were taken. As a result it was the common practice to place large coke stoves or salamanders at each valve station.

Extremes in temperature do not interfere with the operation of the electrical equipment. Maintenance costs and troubles have been greatly reduced and an accurate and an even control for opening and closing the doors is obtained.

FIGS. 2 AND 3—ELECTRICAL EQUIPMENT CONTROLLING THE MOVEMENT OF THE FURNACE DOORS

At the left in Fig. 2, the equipment is located at the rear of the furnace. The cable from each door comes over above and down behind the furnace to cranks driven by these motors through a specially designed spur gear connected to a worm reduction unit.

Smithsonian Institution Makes Appeal for Information on Exhibition Material

TO STIMULATE public appreciation of the importance of steam power plant engineering the Smithsonian Institution is developing a unit of the National Museum in Washington that will show the most significant steps in the evolution of this branch of engineering science. About 3,000 sq.ft. of floor space with 14½ ft. ceiling height will become available in the next few months and will be used for the undertaking.

It is planned to treat the subject in two parts—one, its history, and the other modern practice. The early history is the history of the steam engine; accordingly a series of models will be constructed to illustrate the progress made from the toylike turbines of the ancients to the engines of Newcomen and Watt. A few models of boilers of the seventeenth and eighteenth centuries will be shown, completing the pre-American history.

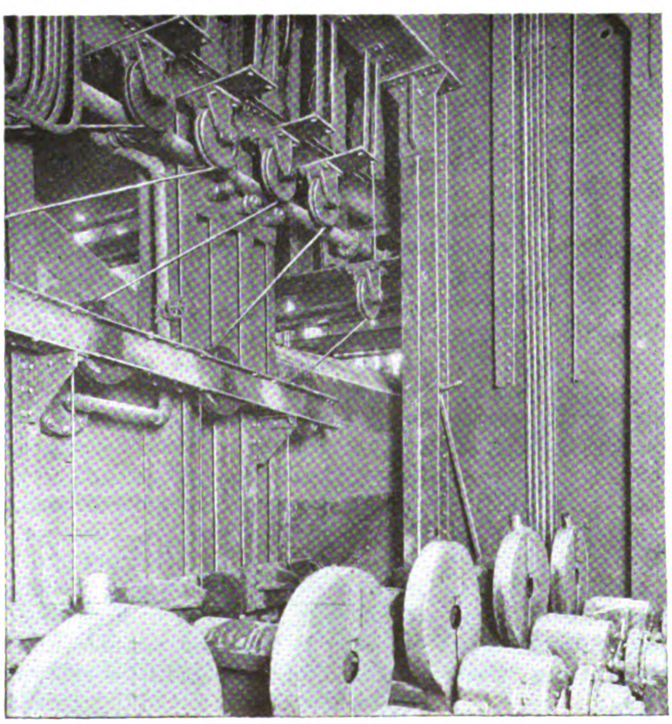
The purely American developments begin after 1755, when the steam engine was first introduced here by Josiah Hornblower. The Institution desires information regarding the location of engines made by Watt, Oliver Evans, John Stevens of Hoboken and Nicholas Roosevelt of New York. Many of these engines were in use and, as it does not seem possible that objects of the nature of a steam engine should not have left a trace, the Institution hopes to locate one or more to complete the exhibit.

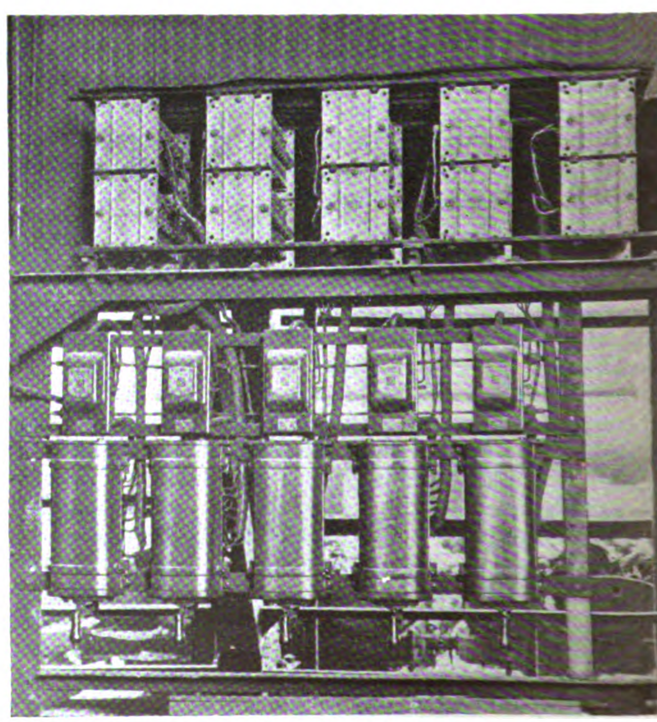
The Museum has the only remaining relic of Hornblower's engine, namely, a section of the cylinder, and it is planned to exhibit with the relic a miniature restoration of the engine on its original location.

The Institution makes an appeal for information of any sort relative to the engines of Watt, Evans and Roosevelt; information as to the existence of any steam engines earlier than 1830; of an early Corliss; and of early types of steam engine and boiler equipment.

Watt sold several engines to purchasers in New England. Oliver Evans, our own pioneer engine builder, had by 1815 constructed some fifty engines at his plant in Philadelphia, Pa. His engines were in use in Providence, Marietta, Philadelphia, as well as in the states of Florida, Louisiana and Mississippi.

It would also like to have information regarding appropriate exhibition material for both the historic and the modern parts of the proposed exhibit. Many plant engineers, sales engineers and erection men are aware of power plant equipment that would be suitable and acceptable to the Museum, and many organizations have or might be interested in preparing educational material visualizing modern practice which would be suitable for carrying out the Museum plans.





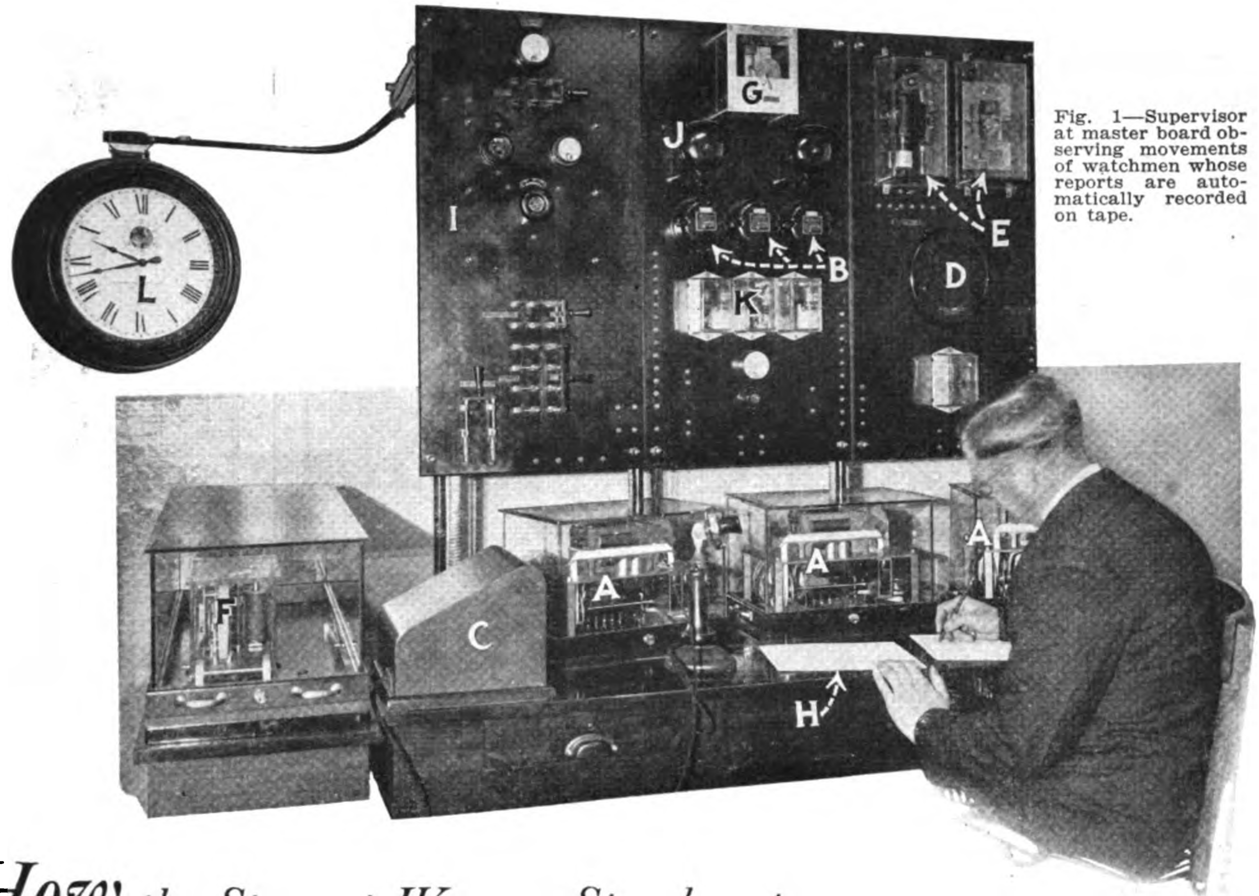


Fig. 1—Supervisor at master board observing movements of watchmen whose reports are automatically recorded on tape.

How the Stewart-Warner Speedometer Corporation maintains supervision over

Fire *and* Watch Service

By J. A. Kaupel
Chief, Fire and Watch Service

SUPERVISION is one of the most difficult problems in connection with handling night watchmen. The only adequate and reliable method of supervision, we believe, is some means whereby all activities of the watchmen are permanently recorded under the observation of a supervisor. In addition, it is advisable to have some automatic check on the supervisor and on the mechanism used. Such is the basis of the system in use. A fire alarm and recording system are also incorporated.

Before going further into the details of our fire alarm and watch system, let us first take up, briefly, some of the plant conditions and the protection against the fire hazards. The plant is a sprinklered, six-story, reinforced-concrete structure 600x250 ft., which is subdivided by firewalls into nine sections, which we designate as buildings, with each given a number. The products manufactured are: automobile accessories, radio sets and other devices. Fire protection is absolutely indispensable, because any lengthy interruption to production would seriously affect practically all automobile plants.

Fire protection must be provided when the building is occupied and also when unoccupied. Gasoline, which must be used for testing and for some cleaning purposes, is the most serious hazard. Both automatic and hand extinguishers are available, in addition to the sprinklers, for both day and night protection. Soda-acid extinguishers of 2½ gal. capacity are placed around all sawdust, excelsior, paper and packing hazards; 2½-gal. Foamite hand extinguishers are at the minor gasoline and oil hazards, and 5-gal. automatic Foamite extinguishers, which are controlled by a Lowe release or a fusible link, are placed above all gasoline, japan, lacquer and paint tank hazards. When the heat rises sufficiently the contents of the extinguisher are automatically dumped into the tank, which smothers the fire. When the hazard

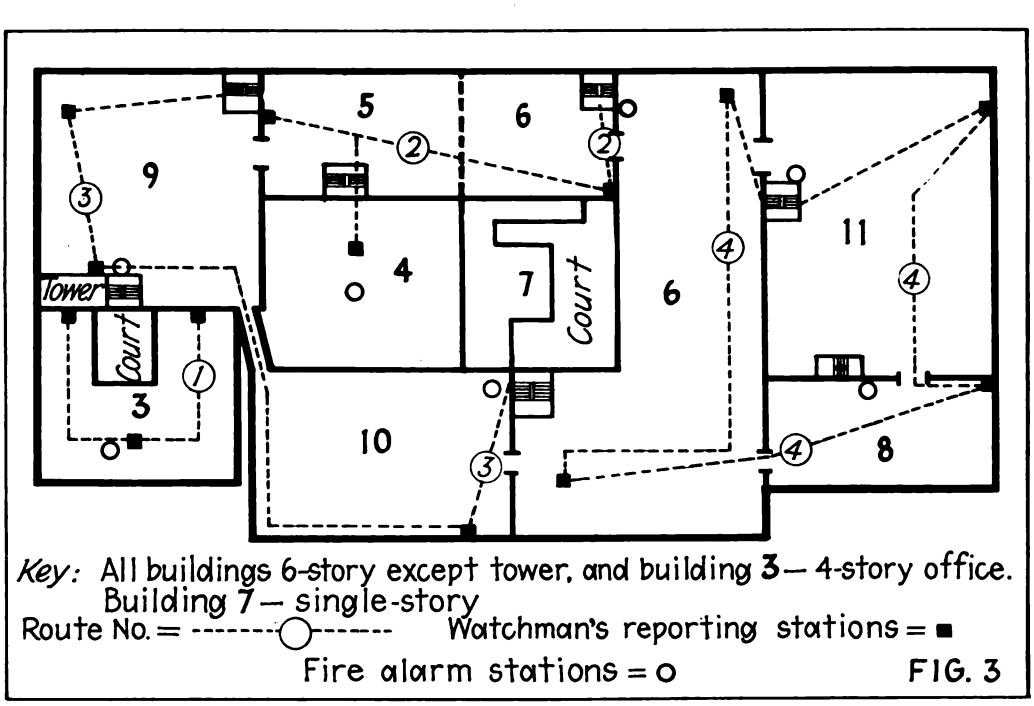


FIG. 2—WATCHMAN REPORTING FROM WATCH STATION
FIG. 3—FLOOR PLAN SHOWING ROUTES AND LOCATIONS OF FIRE AND WATCH STATIONS
The watch boxes are located so that the watchmen must go through a building to get to them. When the watchman turns his key in the box, the coded box number and the time are recorded in one of the recording units *A*, Fig. 1.

is small or where girls, who could not handle the 5-gal. extinguishers, are working, 1-qt. carbon-tetrachloride extinguishers are installed on practically every column. Carbon-tetrachloride extinguishers are inspected monthly and soda-acid and Foamite extinguishers refilled annually, providing they have not been used.

The gasoline is stored in underground tanks and piped to the various floors, but all tanks or vats in the building must be drained back at night. Also, the sweepers work 30 min. later than the shop forces to remove oily waste or wiping rags and any loose combustible material, because obviously, spontaneous combustion is one of the most serious night hazards. Neglect to drain all gasoline containers or remove oily waste and rags, is considered by the company as a very serious offense.

The night watch routes were planned so that the watchman must enter every room and cross to the far side of it. Also, he is not hurried too much; time is allowed for inspection or other tasks. The approximate locations of the watch boxes on the four routes are shown in the accompanying floor plan, Fig. 3, although the arrangement varies slightly on the different floors. The dash line shows the path traveled by the watchman who practically reverses his steps on the next floor below, and so on as he winds back and forth on his way.

A watchman does not stay on one or two floors, but inspects one or two buildings from top floor to basement; thus each watchman travels on all floors. An advantage of this is, because the doors in the firewalls are in line and left open, the watchman can see from one end of the building to the other. On his first round the watchman inspects all doors. Any unusual light, sound or smell in the other end of the building must be reported or investigated. The routes are planned so that about every 20 min. a man passes through a firedoor where he is in a position to look up and down each main aisle the length of the building. If the doors were kept closed, each man could see only his section of the plant, which would be left unguarded until he returned an hour later.

KEY TO INSTRUMENTS ON CONTROL BOARD

A—Watchmen's supervisory recording unit
B—Buzzers for recording units
C—Paging and telephone unit
D—Cut-out and cut-in for elapsed-time indicator
E—Elapsed-time indicator
F—Fire alarm recording unit
G—Dual control
H—Checking sheets
I—Charging panel
J—Trouble bell on fire alarm box and bell circuits
K—Supervisory relays on fire alarm box and bell circuits
L—Master clock

The most important problem, as stated at the beginning of the article, is seeing that the watchmen follow their routes. The supervision we use is a combination of manual and mechanical with an aumotatic mechanical check on the watchmen and their supervisor. Both fire alarm and watch service are recorded on the equipment shown in Fig. 1, which was made by the Auto Call Company, Shelby, Ohio.

The operation of the watchman's supervisory system is as follows: When the watchman inserts his key in any box on his route, Fig. 2, and gives it a quarter turn, the code number of the box is punched in the tape and the date and exact time operated is printed on the tape, as shown in Fig. 4, by one of the three glass-inclosed recording units *A* on the desk, Fig. 1. This furnishes an unalterable record of the watchman's performance.

The supervisor also enters this time on the checking sheet, Fig. 5. A separate sheet is used for each route. As he fills in the checking sheet in front of him, the supervisor can watch the work of each watchman. The tape, meanwhile, winds up when the next box on that route is operated, so, that, if the supervisor leaves his post, he cannot determine

what boxes were operated nor the exact time of operation during his absence. If he tries to guess when he fills in this checking sheet, Fig. 5, any discrepancy will be discovered when the checking sheet and tape are compared. When the tape is perforated, the buzzer *B*, Fig. 1, for that particular recording unit, gives an audible signal.

In this plant, routes 1 and 2, Fig. 3, are traveled consecutively by different roundsmen, so that one recording unit serves both routes. The watchman on route 2 also makes a trip around the outside of the plant every hour. Two men alternate with the watchmen on routes 3 and 4, so that two men are always available for relief, or emergencies, on their hour off.

Telephone jacks are installed in some of the boxes (as indicated by the "T" in the first column of the checking sheet, Fig. 5) so that the watchman can plug in with his portable telephone, Fig. 2, which he carries with him, and report to the supervisor or call for assistance. In addition, the supervisor can call for any or all watchmen on the Auto Call paging unit, *C*, whenever he has instructions, such as to close windows, assist another watchman, and so on.

Automatic supervision over the supervisor is obtained by means of the elapsed-time indicator. At the beginning of the shift the supervisor inserts his key in the cut-in and cut-out control *D*, Fig. 1, for the elapsed-time indicators *E*. This action is coded and timed on the tape and also connects in the elapsed time indicator *E* between the recording unit and the audible paging signals throughout the plant.

In case the supervisor should be held up, suddenly taken sick, become helpless, or leave his post, a buzzer is sounded at the end of a short interval by a timed contact in the elapsed-time indicator *E*, Fig. 1, and, at the end of another short interval, a general alarm is sounded throughout the plant. The sounding of this general alarm is also coded on the tape with the time. This general alarm can be prevented, however.

At the end of the watch shift the supervisor disconnects the elapsed-time indicator by again inserting his key at *D*. This action is also coded and timed on the tape so that he cannot disconnect his supervisory unit without leaving a printed record. This elapsed-time indicator and the necessity of entering the watchmen's time on the checking sheet, Fig. 5, thus keeps the supervisor, or a relief, at the desk constantly. The supervisor receives 1,004 regular reports from the 77 watch boxes in the plant during each 12-hour night shift.

The two extra watchmen, who make alternate rounds on routes 3 and 4, are available for relief of any watchman or the supervisor and are sent to service trouble calls, such as leaking pipes, or other difficulties which would hold up the route man on his rounds. Watch service on Sundays and holidays is performed by inspectors, trouble men, testers and others who work days in this department. These men are paid extra when they take their turn as watchmen. The night watchmen are given nights off without any deductions.

Each watchman carries only a revolver and whistle in addition to his portable telephone. It is unnecessary for them to carry fire extinguishers,

(Please turn to page 574)

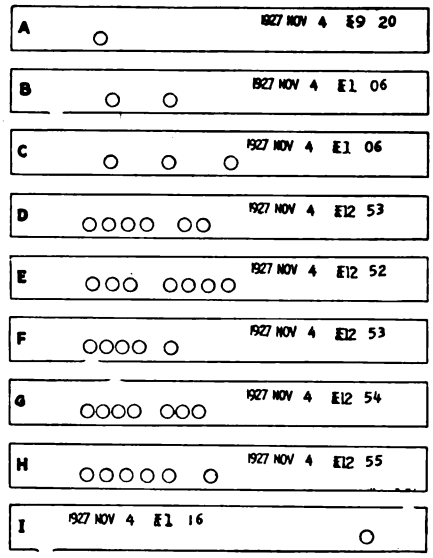
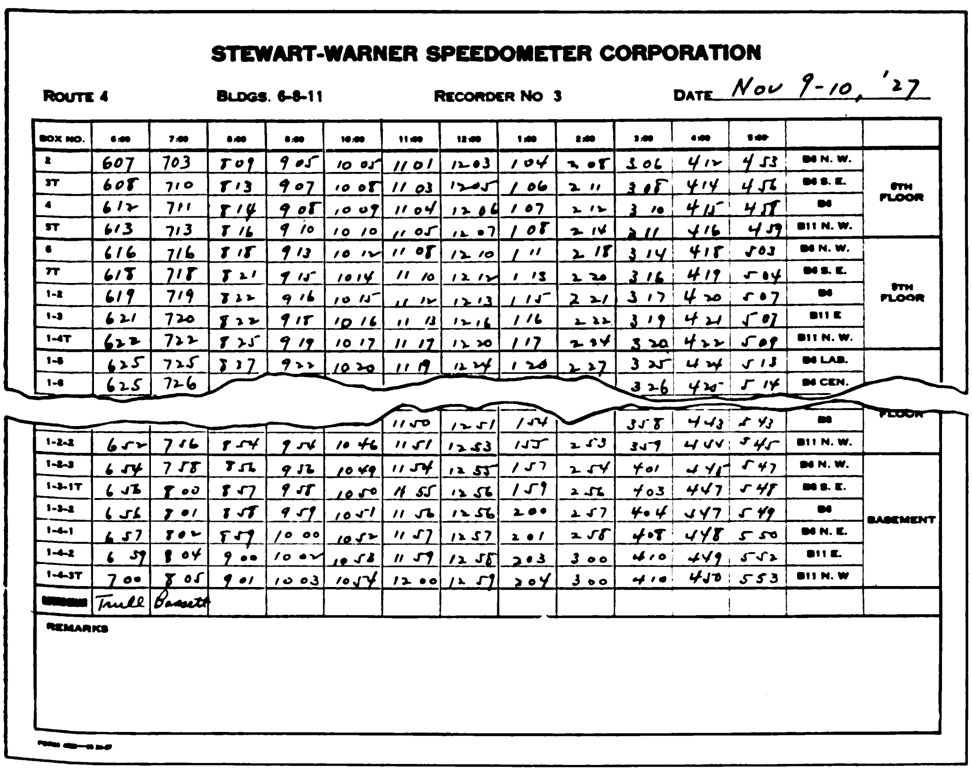


FIG. 4 — EXAMPLES OF CODING TAPE FROM SUPERVISORY RECORDING UNITS

These codes are as follows: *A*—replacing glass case; *B* and *C*—cut-in and cut-out of elapsed-time indicator, respectively; *D* to *H*—codes from various boxes; *I*—removing glass case. Note relative position of code and time stamp as compared to *A*.



STEWART-WARNER SPEEDOMETER CORPORATION

ROUTE 4 BLDGS. 6-8-11 RECORDER NO 3 DATE Nov 9-10, '27

BOX NO.	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00		
2	607	703	809	905	1005	1101	1203	104	208	306	412	453	B6 N. W.	6TH FLOOR
3T	608	710	813	907	1008	1103	1205	106	211	308	414	456	B6 S. E.	
4	612	711	814	908	1009	1104	1206	107	212	310	415	458	B6	
5T	613	713	816	910	1010	1105	1207	108	214	311	416	459	B11 N. W.	
6	616	716	818	913	1012	1108	1210	111	218	314	418	503	B6 N. W.	5TH FLOOR
7T	618	718	821	915	1014	1110	1212	113	220	316	419	504	B6 S. E.	
1-2	619	719	822	916	1015	1112	1213	115	221	317	420	507	B6	
1-3	621	720	822	918	1016	1113	1216	116	222	319	421	507	B11 E	
1-4T	622	722	825	919	1017	1117	1220	117	224	320	422	509	B11 N. W.	
1-5	625	725	827	922	1020	1119	1224	120	227	325	424	513	B6 LAB.	
1-6	625	726								326	425	514	B6 CEN.	
						1150	1251	154		358	443	543	B6	FLOOR
1-2-2	652	756	854	954	1046	1151	1253	155	253	359	444	545	B11 N. W.	
1-2-3	654	758	852	952	1049	1154	1255	157	254	401	445	547	B6 N. W.	BASEMENT
1-3-1T	655	800	857	958	1050	1155	1256	159	255	403	447	548	B6 S. E.	
1-3-2	656	801	858	959	1051	1156	1256	200	257	404	447	549	B6	
1-4-1	657	802	859	1000	1052	1157	1257	201	258	408	448	550	B6 N. E.	
1-4-2	659	804	900	1002	1058	1159	1258	203	300	410	449	552	B11 E.	
1-4-3T	700	805	901	1003	1054	1200	1259	204	300	410	450	553	B11 N. W	
[redacted]	Trull	Bassett												

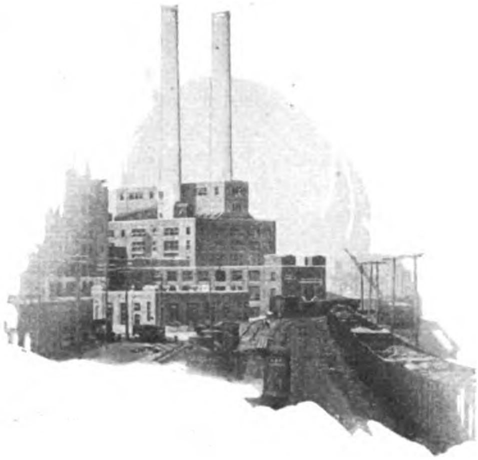
REMARKS

FIG. 5 — PORTION OF CHECKING SHEET ON ROUTE 4

This sheet is filled in by the supervisor from the record as entered on the recording tape by the two watchmen, who make alternate rounds on this route. The letter *T* in the first column indicates that a box has telephone connections for the portable sets carried by the watchmen.

The most important requirement of

Winter-Time Painting



is to have the surface in the proper condition

—writes

F. E. Gooding
Associate Editor
Industrial Engineering

MAINTENANCE painting in industrial plants is usually planned so that outside surfaces are painted during warm weather and the men are moved to inside work when it turns cold. This is an ideal arrangement because the personal comfort of the men is a serious drawback to any outside winter activity, such as painting either by hand or air brush, which require the movement of hand or fingers. Also, advantage is taken of the weather which, in summer, dries both the surface to be covered and the freshly applied protective coating more quickly than in winter.

Whether painting of outside exposed surfaces is practicable in winter depends entirely upon the surface and on climatic conditions. For example, painting in sections where the weather is warm during the winter should be satisfactory except, perhaps, as rainy seasons may affect the surface. Some railroad companies paint rolling stock the year around. Their problem, to a large extent, is quite similar to that of the average industrial plant.

Practically all of the common paints are a mixture of an oil, such as linseed or china wood, a pigment for color, and lead oxide or some other material to give it body. As the oil oxidizes it forms a hard protective covering. The rate of oxidation increases with the temperature. Some paint manufacturers do not recommend painting when the temperature is below 65 deg. F. This is largely because of the necessity of using thinner and dryer for hand brushing at the low temperature. Also, paint requires about 48 hours to dry with ordinary temperatures and longer according to the decrease in temperature. At temperatures below freezing the oxidation action is dormant. Linseed oil has a freezing point of 18 deg. F. below zero.

Certain requirements govern all painting, irrespective of the season, and when these facts are understood, and paint is applied accordingly, the success and lasting qualities of the protective coating may be assured.

The most important of these requirements is to have the surface in the proper condition. Removing dirt, rust, using filler when necessary, and other surface treatments are always preliminary to all painting, irrespective of the season, and so will not be discussed here. There are, however, a number of conditions to be observed in connection with painting which are influenced by seasonal or climatic conditions. The most important of these is to have a dry surface.

When paint has been applied over a surface containing moisture, the application of outside heat, either from direct sunlight or during the summer, will "bring out the moisture" and in doing so, it simply pushes the paint away from the surface. If the surface contained a considerable amount of moisture, practically all of the paint will come off; if the moisture content was small or concentrated, the paint forms "blisters" at those spots when the weather warms up.

Winter painting is not analogous to winter building. The sand and water for mortar are heated and are used in sufficient volume to retain this heat long enough for the mortar to set before freezing. Paint cannot be heated above normal summer temperature and also it is applied in too thin a coating over a cold surface for this heat to have much effect. One of the accompanying illustrations shows a type EM DeVilbiss heater attached to a paint container, which sets in a hot water bath. This heater is used for outdoor winter painting and also in unheated buildings.

Painting Absorbent Surfaces

Absorbent surfaces, such as brick and concrete, are seldom free enough from frozen-in moisture to risk winter painting. These surfaces are difficult to dry out and, after a warm day, frequently condense and regain sufficient moisture at night to interfere with paint applied the next day, particularly if the work is done before the walls are warmed up by the sun, or on a north side of a building which does not receive any direct heat from the sun.

Considerable care must also be taken to see that absorbent walls are

fairly dry before painting on the inside. For example, a concrete wall which is waterproofed or dampproofed on the outside can be painted satisfactorily on the inside in the winter time if the building has sufficient heat to dry out the concrete wall. If the outside is not waterproofed or dampproofed and the building is heated after painting on the inside the heat sometimes "draws" the moisture toward the paint and "pushes" it off the wall. The remedy with porous walls, is to first waterproof or dampproof the outside and then thoroughly dry the wall by heating it from the inside before painting. Water- or dampproofing coatings, which have a cold water base, cannot be applied during freezing weather.

When new buildings are erected during cold weather the mistake is sometimes made of painting inside plaster and tile or cement walls while yet "green," that is, before the building is thoroughly dried out. The same precaution is necessary in warm weather but then the walls dry out much more quickly. The danger in winter lies in mistaking surface drying, such as may result from too high a drying temperature, for a thorough job. Similar precautions are required when painting the interior of unheated warehouses or other buildings.

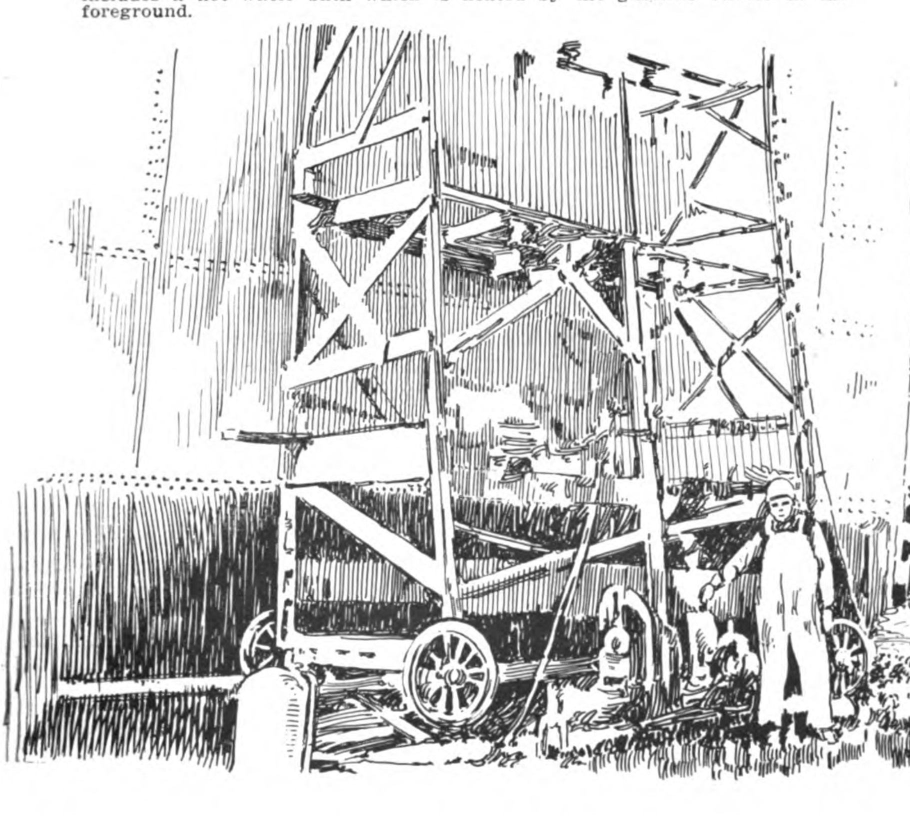
Wood offers an absorbent or non-absorbent surface according to the condition of the paint coating previously applied or if unpainted. However, there are many instances of successful application of paint to such cases. The experience at one plant indicates the possible danger of improper application.

During a warm period in a so-called dry winter the manager of one factory ordered the painting of a new, unpainted wooden building. The next spring the east, south and west sides of the building were entirely satisfactory with the exception of a few spots. Practically all of the paint on the north side however, blistered or peeled off. The same kind of paint had been used throughout; therefore, the material was not responsible.

The theory advanced by the paint service engineer who was called in, was that during the day the sun had dried the three sides of the building sufficiently to permit satisfactory painting. The north side, warmed up only enough to condense moisture from the air which would freeze again at night. If the surface has been well protected with previously applied coat of paint and only a new coat or color change was desired the work would probably have been satisfactory on all sides of the building. A wooden surface, which is badly in need of paint, may absorb sufficient moisture to affect the lasting qualities of the paint, when the moisture dries out.

Dry, metallic and other non-absorbent surfaces can be painted in cold weather with the least chance of unsatisfactory results. However, a metallic surface which has been painted once is less likely to be damp from frost or moisture condensed from the air. The difficulty comes in connection with applying the paint, which stiffens with low temperature. Even 10 deg. F. will make a difference in ease of application by the use of the hand brush.

Assuming that it is a hand brush job paints will "drag," or "crawl." A thick paint "drags," that is, it is too stiff to brush onto the surface and drags, which increases the difficulty of hand application and often results in an uneven coating. Where the paint is thinned to prevent drag it sometimes "crawls," that is, it is so thin that it will gradually flow as a surface, or crawl by gravity. This also results in an uneven application. Paint when applied in a thick coat by an air brush is also likely to crawl because the attraction of gravity is greater than its adhesion power before it begins to set, which takes place slowly because of the low tempera-



FOUR BELOW ZERO! THE SPRAY GUN IS BEING USED TO PAINT THESE OIL TANKS IN WYOMING

The rubber-tired, movable scaffold reaching to the top of the tank is a novel idea and well worth remembering. Paint for spray gun use in low temperatures is kept warm by the equipment shown at the right. The container includes a hot water bath which is heated by the gasoline burner in the foreground.

ture. To prevent crawl the painter usually adds some quick drying agent.

Some climatic conditions and geographical occasions are better suited for cold weather painting than others. For example, painters in parts of Canada and the United States, particularly those sections which have dry summers, and "dry cold" winters report successful paintings of large areas when the temperature is below zero. One of the illustrations accompanying this article shows a painting scaffold on wheels which was used to paint oil tanks in Wyoming with a Paasche air brush when the temperature was 4 deg. F. below zero.

If sufficient area is to be covered to make mechanical painting worth while such equipment can be used as well in winter as in any other season. A thicker paint can be better applied mechanically than by hand. The only difficulty which may interfere with the use of the paint spray is in connection with the condensation of moisture in the air compressor, receiving tank and the hose line. The moisture which forms in the air receiver may be removed by opening the valve in the bottom and "blowing" until the air seems to be dry. Also, it is advisable to place an air conditioner between the air receiver and the paint container to prevent condensation in the main air hose. Unless the moisture is removed the regulators may freeze. If moist air is permitted in the air hose to the gun the moisture may condense and freeze in low spots in the hose, particularly if it lies on the ground.

The gas engine and air compressor require the use of a lighter oil in winter than in summer. Also, the gas engine, if water cooled, must be drained at night to prevent freezing and bursting the jacket.

Professional painters in the region of the Great Lakes and other localities which generally have a damp atmosphere during the winter hesitate to do outside work except of small areas when the day temperature gets as low as 40 deg. and below freezing at night. These men have had wide experience with paint and know how much thinner or dryer can be added for each particular condition.

It is stated that paint containing about 20 to 28 per cent of zinc oxide makes a good outside paint to apply in winter. Another mixture, which was given by a practical painter, for use on surfaces that may be somewhat frosted or damp is as follows: The liquid or vehicle consists of equal quantities of gloss oil, kerosene and linseed oil. Equal quantities of metronite and white lead are mixed in the vehicle to the desired consistency. Metronite is in powder form. It is stated that this paint has been used successfully in Michigan in cold weather, has good lasting quality, and is low in cost.

The average industrial painter, however, will usually find it to his advantage to postpone extensive painting projects until warm weather and do inside work. However, on bright days hydrants, downspouts, window sash and a wide variety of small paint jobs can be finished with satisfactory results. It is better to paint such surfaces in winter than not at all; but for protection against the elements, new work requires a priming coat or two. When warm weather comes the painter will soon learn whether it is going to stick and he can then brush off the loose particles and finish the job.

Fire and Watch Service

(Continued from page 571)

which are available in all parts of the plant. An extinguisher would be an unnecessary load, even though only able-bodied watchmen are used.

The automatic recording unit *A*, Fig. 1, is motor-driven and has automatic supervision. The circuits on which the watchmen report, are normally closed. In case a circuit should open, the tape runs continuously. This can be stopped only after opening the glass case and throwing a control switch which lights a red lamp as long as the trouble exists. Opening the case is recorded by a special code, Fig. 4, and timed on the tape.

The watch service is for protection when the plant is unoccupied. The fire-alarm signal system, however, serves both day and night. The watchmen may report fires to the supervisor by telephone, but we urge that the fire alarm boxes and alarm system be used. There are 40 red break-glass-front Auto Call alarm boxes in the plant on seven circuits. The watch boxes which are blue, are placed where they are more difficult of access. However, the fire alarms are conspicuously located at exits, elevators, stairways or passageways, where usually they are convenient to two buildings and where every workman can see them as he passes in or out of his floor. Fig. 3 shows the location of the fire alarm boxes on one floor. A city fire alarm box is placed on the street outside the watchmen's headquarters. Also, a direct line to the telephone exchange enables the supervisor to report a fire by telephone.

When a fire alarm box is put in operation, by breaking the glass front with a hammer, the fire signal recording unit *F*, Fig. 1, perforates the box number on the tape and prints the date and time similar to that on the watchman's tape, except that it is repeated three times. A sufficient length of tape is exposed so that the record is not covered up, as is the case when the watchmen report at a watch box. Simultaneously, the Auto Call paging system is automatically cut out by the dual control unit *G*, Fig. 1, and ten rapid signals sounded throughout the plant to indicate that a fire call is coming. This is immediately followed by the code number of the box, repeated three times. The dual control unit *G*, through the relays, also cuts in the fire-only circuits for the alarm.

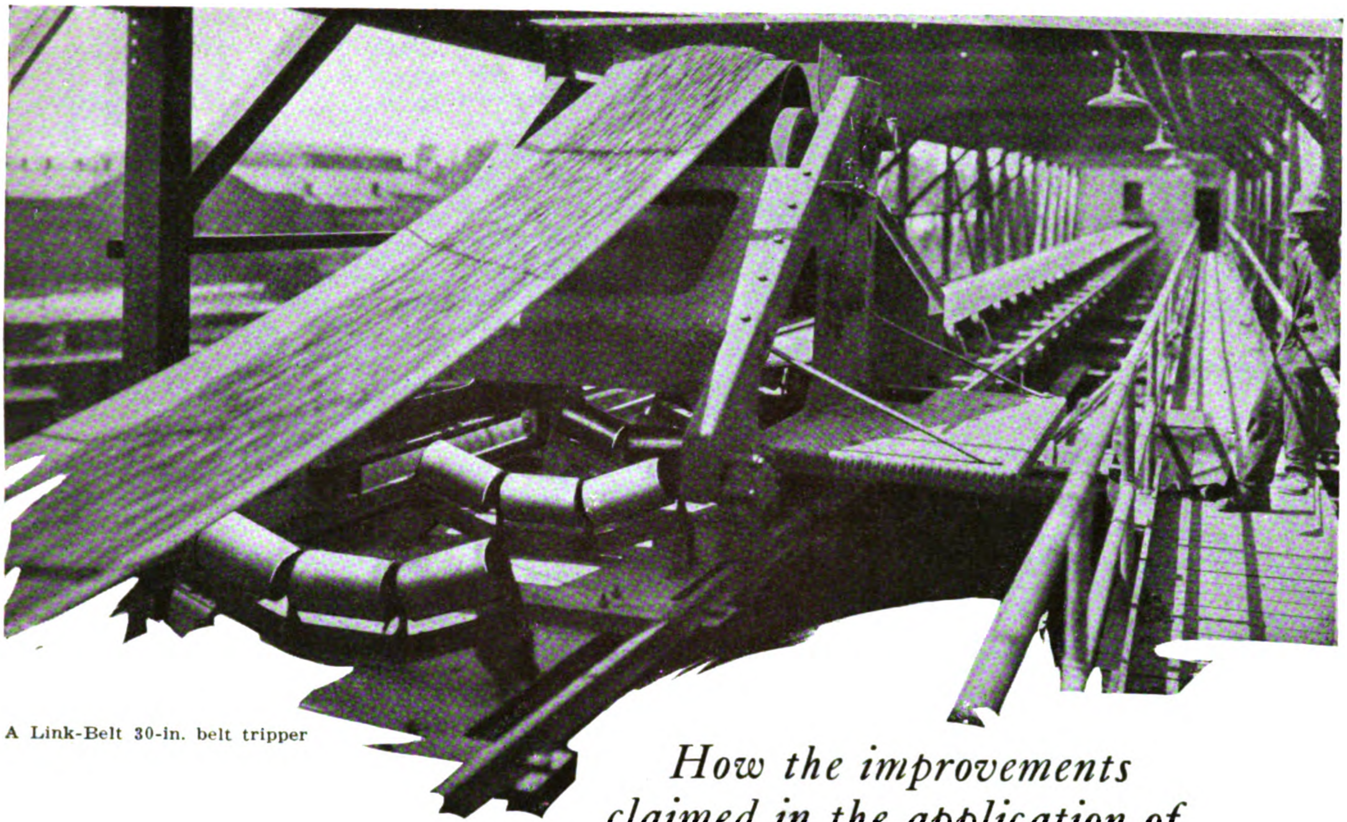
This dual control is operated by a clock spring. However, when the spring is dissipated to a certain point, a special trouble signal sounds on a bell until the spring is wound.

A trouble bell on the fire alarm box circuits indicates any failure or interruption of the power source by opening a relay which cuts in the 110-volt, 60-cycle lighting circuit, to operate a trouble call.

Fire alarm box circuits, the night watch box circuits and the fire-only signal circuit, are all normally closed and supervised and supplied from either of two banks of 48-volt Exide storage batteries. Usually one bank of batteries is charging while the other is in use, but if necessary, connection can be made to the battery under charge and the Tungar rectifier floated on the line. This practice is to be used only in emergencies because a slight hum interferes with the telephone service.

As a further check on the fire alarm circuits and box mechanisms, one or more boxes in each of the seven circuits are operated daily. By selecting a different box each time, the entire system is operated every week.

Although this watch and fire alarm equipment has been in operation only a short time, we can see a decided improvement in the service and interest the watchmen take in their work. Also, we feel an added security in that we know very closely where every watchman is and can locate him at any time. In addition, we have two records of his work.



A Link-Belt 30-in. belt tripper

How the improvements claimed in the application of

Roller Bearings to Conveyors...

are actually secured

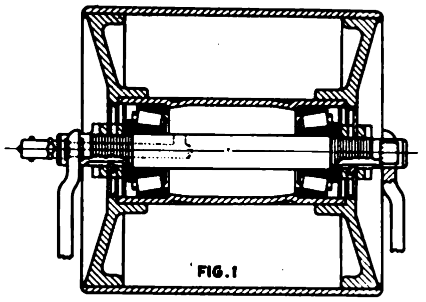
Explained by
S. M. Weckstein
Industrial Equipment Engineer, Timken Roller Bearing Co. Canton, Ohio

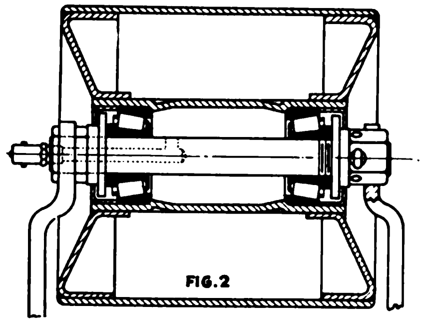
SINCE conveyors, of all types, have proved themselves the most efficient, and are consequently the most used medium for handling certain classes of bulk materials, they have naturally been brought to a high state of development, both physically and mechanically. Nevertheless, certain problems in connection with their design still remain, the solution of which has a decided influence on their performance from both a practical and an economic standpoint. And while many of these problems arise out of the particular conditions under which individual conveyors must work, which vary so much that usually they have to be solved according to the requirements of each particular case, there is one problem which is common to all cases—that of obtaining the greatest amount of work per unit of power input.

This problem assumes the proportions it does because conveyors of any type whatsoever represent, from a driving standpoint, primarily a friction load to a degree that may be aggravated, but is seldom lessened by any one of many factors that may be encountered in service. A brief summary of these would include: the type of conveyor; the sort of material handled; the distance traversed; the conditions of loading; and the convenience and frequency of lubrication—the latter of which is usually dependent upon the former.

Many methods which met with varying success have been tried in the effort to reach a satisfactory solution of the problem, but few of them have proved really satisfactory. Comparatively recently a remedy has been adopted which attacks the trouble at its source—the application of anti-friction bearings to the conveyor rolls, and drive mechanism. The results have been remarkably successful especially from the standpoint of improved operating practice and economy, sufficiently so at least to thoroughly establish the practicability of the method. For this reason it might be of interest to consider the engineering features of the application of the bearings to different types of conveyors, inasmuch as it is from such a description that the best idea can be obtained of how the improvements claimed are actually secured.

Since belt conveyors are the most widely used, and also present the most difficult problem in so far as their drive is concerned, it is logical that they should have been the first to receive attention. From a construction standpoint the application, especially of tapered roller bearings, to the rolls is a very simple matter, the only important requirements being that ample provision must be made for the





FIGS. 1 AND 2—TYPICAL BELT CONVEYOR ROLLER APPLICATIONS

The bearings are mounted in a tube or shell, which carries the body of the roller and which is constructed so as to form a perfectly dust-tight and leak-proof reservoir for the lubricant. Fig. 1 shows one form of bearing mounting and the method of retaining the lubricant. Another type of mounting employing a simpler method of retaining the lubricant is shown in Fig. 2.

storage of enough lubricant to last over a considerable period, and that the possibility of the entrance of dirt or other foreign matter into the bearing housing must be eliminated as nearly as possible. Although the actual details of such construction are usually a matter that is decided upon by the conveyor builder, experience has developed a more or less conventional sort of construction that will serve to illustrate how the requirements are met.

As can be seen from Figs. 1 and 2, which are typical rollers, the bearings are mounted in a tube, or shell, which carries the body of the roller, and which is constructed so as to form a perfectly dust-tight and leak-proof reservoir for the lubricant. The cups or outer races of the bearings are usually pressed into the tubes, and the cones given a slightly loose fit on the shaft, but not so loose as to permit any slippage.

By virtue of this construction, not only is shaft wear prevented, but there is no likelihood of the bearing seizing, and causing the roller to wear spots on the belt. Lubrication in most modern installations is accomplished by the grease pressure method, the roller shaft either being counter bored, or left hollow, to permit access of the grease to the interior of the tube. There are various ways of constructing the outer closure, both simple and complex, but in either case it is easy to work out an inexpensive method that is highly effective, such as the use of labyrinth washers, for example.

In the case of the larger rollers, concentrator rollers, return idlers, or others where for various reasons it is impractical to use the whole interior of the tube for holding lubricant, a different arrangement has been adopted which is shown in Figs. 3 and 4. In these two cases the tube mounting of the bearings is dispensed with, the roller being so constructed that the bearing cups can be pressed directly into the end frames, which are so designed as to form an inside seal for retaining the lubricant in the bearing chamber. The method of introducing the lubricant is the same—by boring and counterboring the shaft to afford a passage from the exterior to the reservoir. As a usual thing, the exterior closures are of the same construction as in the other rollers. An extra precaution is sometimes taken to seal the lubricant more positively in the lower bearing of concentrator rollers.

In the case of some flat-belt return rollers, where the tube bearing mounting is retained, the lubrication reservoir space is provided for by a large punched steel stamping or retainer, which fits closely around the shaft,

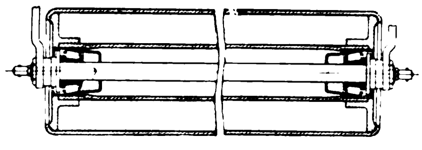
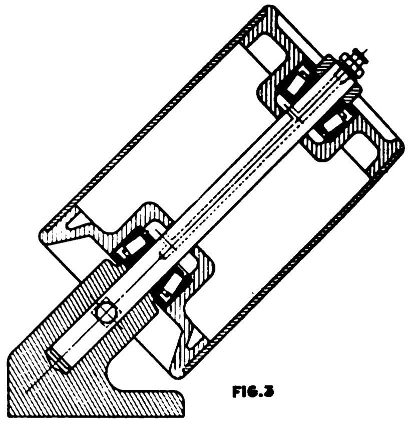
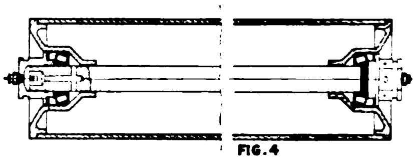


FIG. 5—FLAT BELT RETURN ROLLER SHOWING MODIFICATION OF TUBE MOUNTING

The method of supplying the lubricant is the same as that shown in Figs. 3 and 4.



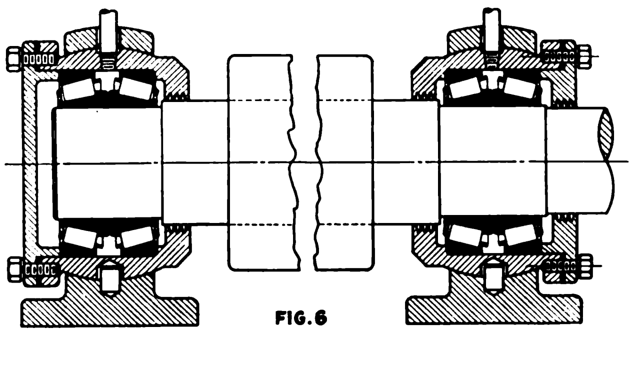


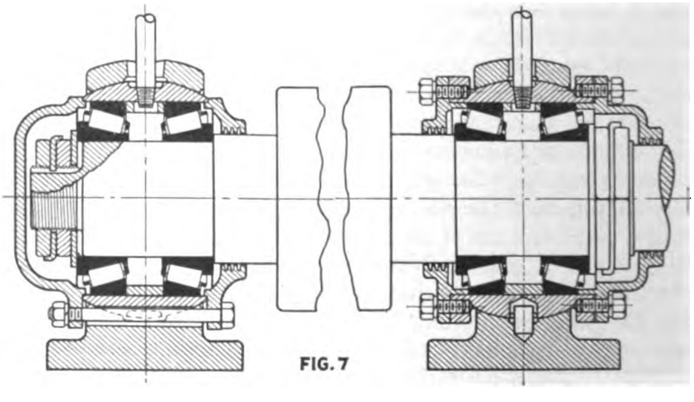
FIGS. 3 AND 4—BEARING ARRANGEMENT ADOPTED FOR LARGE ROLLERS

In these two cases the tube mounting of the bearings is dispensed with, the roller being so constructed that the bearing cups can be pressed directly into the end frame. The method of providing lubricant storage space around the bearings for concentrator rollers or belt conveyors is shown in Fig. 3. A flat belt return roller with bearings mounted in the web extension is shown in Fig. 4.

FIGS. 6 AND 7—METHOD OF MOUNTING HEAD OR TAIL PULLEY BEARINGS

Back to back mounting of the bearings is shown in Fig. 6. In Fig. 7, the cups are held apart by a spacing ring. The inside bearing is mounted against a fillet on the shaft, but the outside bearing is properly set up by locknut and washer.





and is pressed into the shell ahead of the bearing cup. This construction is shown in Fig. 5. The method of supplying the lubricant, however, is the same.

The practical reasons for these modifications are easily explained. In the case of concentrator or guide rollers the position in which they are mounted makes it necessary, aside from any consideration as to the mechanical advisability of tube mounting, to provide means for concentrating the lubricant in the immediate vicinity of the bearing to be supplied. Otherwise, the upper bearing would tend to run dry, and the lower would be over-supplied. In the case of return rollers, whether the bearings are tube mounted or not, the volume of the interior renders it impractical to use the whole space as a reservoir because of the waste of lubricant that would result.

Load Characteristics

In order to obtain the fullest benefit from the use of anti-friction bearings in belt conveyor practice, however, the installation should not stop with the conveyor rollers, but should include the head and tail pulleys, take-up pulleys, etc. As can be seen from Fig. 6, the bearing arrangement in the case of the former differs considerably from that found in the conveyor rollers and return idlers, the variation being due principally to the difference in the load characteristics and requirements of the two types of installation.

Since in the latter instance the loads, both radial and thrust, are much heavier, and the matter of holding the shafts in alignment assumes greater importance, it is customary to use two bearings, mounted back to back at each end of the shaft. In some cases they are mounted as shown in Fig. 7, that is, with the cups held apart by a spacing ring, and the cones a light press fit on the shaft, the inside bearing being mounted against a fillet on the shaft, and the outside one properly set up by lock nuts and washers. In other cases they are mounted directly back to back without any spacer, the cones being a metal to metal fit on the shaft. In this case any floating of the shaft that becomes necessary can take place through the cones without disturbing the bearing adjustment. In both cases the bearing housing is of very simple construction, and the facility for storing the lubricant is ample.

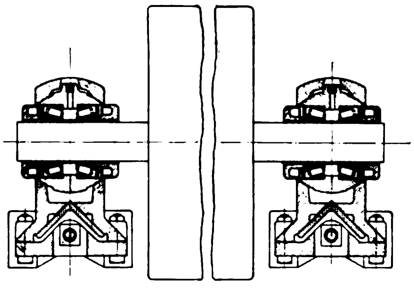


FIG. 8—TYPICAL BEARING MOUNTING FOR TAKE-UP PULLEY
The bearings are mounted so as to give the greatest possible rigidity to the pulley shaft.

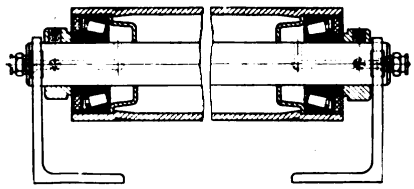


FIG. 9—TYPICAL BEARING MOUNTING FOR GRAVITY CONVEYOR ROLLER
One of the most important mechanical features of this type of application is the necessity for simplicity, and correspondingly low cost in equipping the rolls with bearings.

As far as take-up pulleys are concerned, they are usually mounted between two pillow blocks, in which the bearings are mounted so as to give the greatest possible rigidity to the pulley shaft. Fig. 8 shows a typical mounting of this sort. A standard pillow block, such as can be obtained as a complete unit from the manufacturers, is used in this case. The bearings come properly set up, and it is only necessary to locate the sleeve in the proper position on the shaft, and clamp it in place by the nuts provided for the purpose. The pedestal which holds this pillow block can be designed to provide for the automatic take-up on the belt.

Before leaving the subject of belt conveyors, a type of conveyor should be considered that is closely allied to them, at least as far as the roll construction is concerned, namely, the gravity conveyor. Mechanically, one of the most important features of this type of application is the necessity for simplicity, and for correspondingly low cost in equipping the rolls with bearings.

This necessity arises from the great number of rollers that must be used, in proportion to the length of the conveyor, which would make an expensive form of mounting impractical. Consequently, a very simple method has been worked out, which is largely used, as shown in Fig. 9. It consists of pressing a circular indentation into the roller itself, which provides a shoulder on the inside surface of the roller against which the bearing cup and the grease retainer can be pressed. The outer closure is formed by labyrinth washers, and the whole assembly locked in place by a retaining ring which is held by a set screw. The lubricant is supplied through holes in the shaft similar to those formerly described.

Physical Features

In the case of flight, pan, or apron conveyors, as they are variously known, the physical features of the installation are naturally quite different, as are the load requirements, as far as the bearings themselves are concerned. The same factors concerning lubrication remain, however, in that provision must be made for a supply sufficient to last over long periods. Because the bearings are usually mounted on wheels which are flanged to run on tracks, the thrust loads which are always present in such a combination become an important factor in applying the bearings.

Several methods of mounting have

(Please turn to page 591)

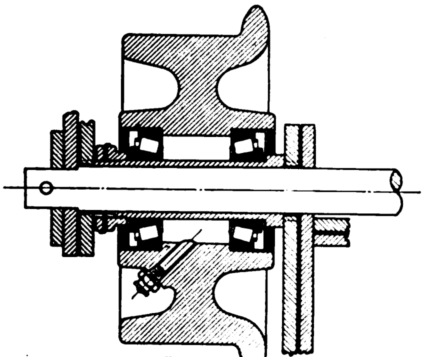


FIG.10

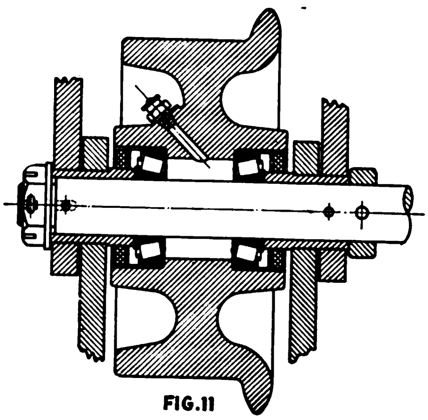


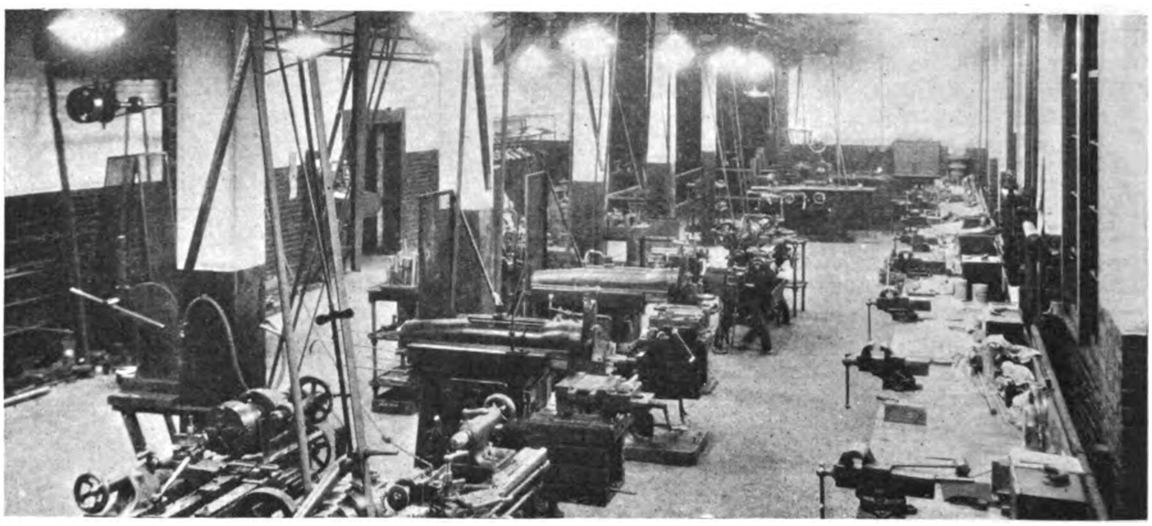
FIG.11

FIGS. 10 AND 11—SIMPLE FORM OF BEARING MOUNTING FOR CONVEYOR WHEELS
The bearing mounting for pan conveyor wheels is shown in Fig. 10. The cups are installed in the usual manner, but the cones are set up on a sleeve. The whole comprises a unit assembly of wheels and bearings. The assembly shown in Fig. 11 is different, in that the cones are fitted directly on the shaft. It does not permit of unit assembly such as that illustrated in Fig. 10.

The best time to put in a new lighting system is when your factory is busy, says

FRANK MILLHOF
Superintendent, Leece-Neville Co., Cleveland, Ohio

Revamping the Lighting System During a Production Peak



General illumination replaced local lighting by drop cords in this tool room

OUR plant is engaged in the manufacture of commercial automotive starting and lighting equipment and voltage-regulated lighting units that are used both by the Government and by industrial plants, railroads and other organizations. I had realized for some time that our lighting was insufficient for a product that had to be made with such accuracy as ours. In particular, the requirements on the outfits supplied to the Government are very strict.

Formerly it was considered that good appearance is not very important in a machine shop. Everyone expected to see a lot of grease and dirt. A light, clean machine shop would have been something of a curiosity. But things are quite different now.

I do not believe that there is any place where lighting and the liberal use of white paint are of more importance than when you are serving the public by furnishing equipment or service of merit. When an army officer, a navy officer, bus operator or railroad official comes in he likes to see everything as clean and orderly as it is in the barracks, on board ship, or in a parlor car. There is nothing that contributes to neatness and orderliness in the way that proper combination of light and paint does. When there is a dark corner or a dark place under a machine, you can be sure somebody will take advantage of it sooner or later as a safe and easy place to throw rubbish or sweep dirt. We have eliminated all such places in our plant. There is not a square foot of floor space that cannot be seen, except where it is taken by a machine that goes right down to the floor of the building.

We had used overhead illumination from the beginning, but the units were small; so we had drop cords everywhere. There was a regular forest of lamp cords and they were always causing trouble. Frequently they got caught in the gears on the machines and were short-circuited, or somebody would pull one a little too hard and break it. Furthermore, in spite of the guards, a great many lamps were broken in the course of a year, which increased the cost of maintaining the lighting system.

A little over a year ago I commenced to look around for a solution, and decided that the only thing to do was to rearrange the machines and clean out all the drop cords in favor of better overhead lighting. At that time we were in the middle of a production peak.

All our machines were busy every minute of the day. However, I believe that the time to make changes in your factory is when you are busy. If you need those changes to produce an extra volume of work, the sooner you make them the better. Besides, it is always easier to put through an improvement when there are plenty of orders on the books.

So I started in on that basis, first obtaining a lighting layout of the entire factory, and at the same time relocating all the machines for most efficient production. We began with

the tool room and put in a lighting system that gives the workmen 19 foot-candles at the level of the bench. In spite of the fact that this department is right up against the windows, the lights are on all the time except on bright, sunny days. We do have some exceedingly fine work, such as cutting a fine and accurate thread or splitting a line in making a die, for which a relatively high level of illumination is required, but only over the small area in which the actual work is done. In these special cases we use a few local lights, but for the vast majority of our operations the present system gives much better results than anything we have ever tried.

The tool room lighting system was put in on a month's trial, but there has never been any question of going back to the old method of lighting. Just as soon as the installation was completed, men in other departments began to ask, "Why can't we have that kind of lighting in the machine shop?" or "Why can't we have such lighting in the repair department?"

Most of the men took to the new lighting from the start. Occasionally I found one who said he preferred a bare lamp hanging before his eyes all the time. In such cases I would ask him to let me make a little test and called one of the other men over. I would ask him to let the light shine in his eyes a few seconds, and then look away from it. Then I asked the man who wanted the drop light to watch the pupils of the other man's eyes while this test was going on. Of course, he saw them close down in the light and open up when he looked away. I just reminded him that this continuous changing of the pupil all day long was extremely tiring, and bad for the eyes. No one failed to appreciate this fact and now everyone is entirely satisfied to work by the general lighting system.

As I have mentioned, we made all of these changes at the busiest time in our history. And we did it without making a ripple in the routine of our production. Practically all of the moving was done at night. A machinist would leave his lathe in one spot at night, and find it at the other end of the shop in the morning. The new lighting system went in just as smoothly. We did not remove any of the old wiring until we had all of the new wiring in and ready for current to be turned on. We went through several of our departments in the same way. All the new units consist of Glassteel reflectors fitted with 200- or 300-watt Mazda lamps and are spaced 10 ft. apart. The mounting height is 9 ft. 6 in. This arrangement gives an intensity of 14 foot-candles, which is used in all of the production departments.

At the present time we are making a considerable addition to our plant, but we are not letting that alter our plans in the slightest degree. I know where every lighting unit in the plant will be placed and we can go ahead any time and equip those sections that require immediate attention. No matter how much or how little lighting equipment is added at a time, I know that it will fit perfectly into the general plan.

There are two points that I should like to pass on from my lighting experience. The first one is: The best time to put in a new lighting system is when your factory is *busy*. There is no such thing as being too busy to give employees the benefit of better lighting. The second suggestion is: Plan your entire lighting installation at one time, so that you know where every lighting unit is to be. Then, no matter where you start, or how many units you install at a time, every one will fit into the general plan. This procedure will save the trouble and expense of moving units later.

A GENERAL VIEW AFTER THE NEW LIGHTING SYSTEM WAS INSTALLED

The Glassteel reflectors containing two 200-watt lamps are spaced 10 ft. apart at a mounting height of 9 ft. 6 in. The intensity of illumination is 14 foot-candles.

New Welded Truss Member Uses Less Metal

UTILIZATION, at less expense, of less metal to withstand a given load in the construction of industrial buildings is made possible by the development of a new design of roof truss by William Dalton of the General Electric Company's manufacturing department. This truss, instead of being riveted, is fabricated by welding.

The truss consists of two parallel lengths of metal latticed together by a system of tension and compression members, rivets heretofore being used to fasten the units together. The use of rivets, however, necessitates punching holes in the truss members, and these holes cause a waste of material. This loss, says Mr. Dalton, is equivalent to a strip of metal the full length and thickness of the part in which the hole is punched and as wide as the diameter of the rivet which is used.

In the new truss, the two parallel members or cords are made of H beams; the tension members are of channel iron and the compression members, H beams. As an economical fastening is needed and as it is not easy to rivet such a combination of shapes together, welding is used to make the necessary connections. This also avoids the waste of metal caused by rivet holes, and furthermore does not require the use of gusset or connecting plates necessary for riveted joints.

A long series of tests has proved that a definite size of weld of a given length made with a specified current and electrode has as definite and dependable holding value as an ordinary rivet.

A comparison of riveted and welded trusses designed for the same load and stresses shows that the riveted trusses are about 40 per cent heavier than the welded trusses.

// INDUSTRIAL ENGINEERING
with which is consolidated
INDUSTRY ILLUSTRATED
Electrical, Mechanical and Plant Service in Industry
G. A. VAN BRUNT, *Editor*
Published by McGraw-Hill Publishing Company, Inc.
JAMES H. MCGRAW, *President*

New York, December, 1927

Buying According to Specifications Can Be Overdone

PURCHASING materials and supplies according to carefully prepared specifications seems to be a growing tendency in industrial plants. The establishment of such quality standards is a commendable practice and its extension is well worth considering. However, like with many other practices and policies, this feature of purchasing is being overdone in some cases. Also, as is almost inevitable when specifications are prepared at individual plants, there is comparatively little co-ordination in requirements.

This is pointedly emphasized by data compiled by a belt manufacturer. Approximately twenty of his customers have prepared their own belt specifications. Of these, no two are exactly alike in their requirements. Some have specifications which vary so slightly from the characteristics of the standard belt made by this company that it would require more careful tests than the average user could make to determine whether their requirements were complied with. Still other specifications impose changes in the manufacturing methods, some of which the manufacturer believes do not give any appreciable increase in quality but increase the cost and add to the inconvenience that always accompanies special orders.

The manufacturer would unhesitatingly guarantee his regular first-quality product for the ordinary requirements of his customer. But as each of these customer's specifications is designed to obtain simply a standard first-quality belt, the manufacturer properly feels that he cannot offend the laws of economics by getting out something "a little different" for them when standard goods will apply.

Manufacturers of lubricants, paints and numerous other supplies used in industry are confronted with similar "home-made" specifications. In several cases, due to error in analysis or to a lack of technical or manufacturing knowledge, the specifications have contained conflicting or impossible requirements. In some instances a product compiled according to the specifications would not be at all similar to what is wanted.

Analysis and testing of belts, lubricants, paints and a number of other industrial supplies require not only special laboratory apparatus but a technic which can be obtained only through experience. The small industrial user must rely upon the recommendations of manufacturers. He establishes a contact with a reliable maker and buys standard, which are usually branded, goods. In many ways the quality and usefulness of the supplies he buys are better assured than are those of the buyers who attempt to tell manufacturers with long experience in special lines how to make their product. Where specifications are necessary, standards, which can be used, have been prepared by the Bureau of Standards, the associations of the manufacturers or other bodies, after due investigation of the problems of both manufacturer and user.

Do Your Men Know What to Do In an Emergency?

WHEN the recent flood in New England suddenly swept over one large plant on a Saturday evening, the confusion among the few men on duty can easily be imagined. All employees who could be reached by telephone were summoned and in a very short time every precaution that could be thought of was being taken to minimize damage. Although a most creditable job was done, considering the circumstances, it is only natural that some things should have been overlooked. One of these items was a number of large cans of calcium carbide.

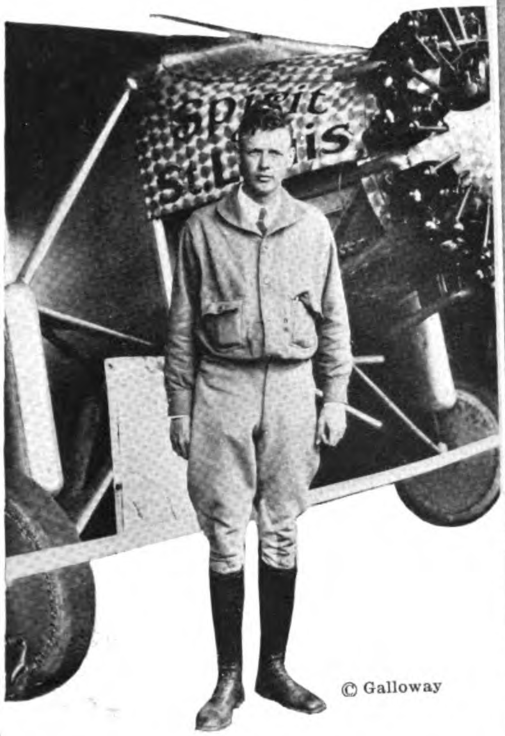
This company has a central acetylene generating plant and the raw material, carbide, was stored in a supposedly safe place. In the excitement no one thought about the cans of carbide until a strong odor of acetylene gas showed that the water had reached them.

Removing these cans to a safe place was a difficult and dangerous job. Despite the fact that some were so hot they could hardly be touched, the workmen had to carry them in their arms to a safe place. Luckily, no one was injured, although the chances in favor of a serious accident would seem to have been great.

As a result of this and other lessons learned during the flood, the plant engineer purposes to write down a detailed list of the things to be done in the event of another flood. These jobs will be set down in the order of their importance.

This plan could well be adopted in almost any plant. Although a great many plants, fortunately, are in little danger of floods, fire is an ever-present menace in all plants. In many others, processes that employ high temperatures, or pressures, or in which explosives or inflammable liquids are used, may present definite and serious hazards.

Concise directions telling just what to do in an emergency will go a long way towards minimizing damage, and insuring intelligent direction of efforts.



© Galloway

©Wide World

Take a Tip From These Fliers

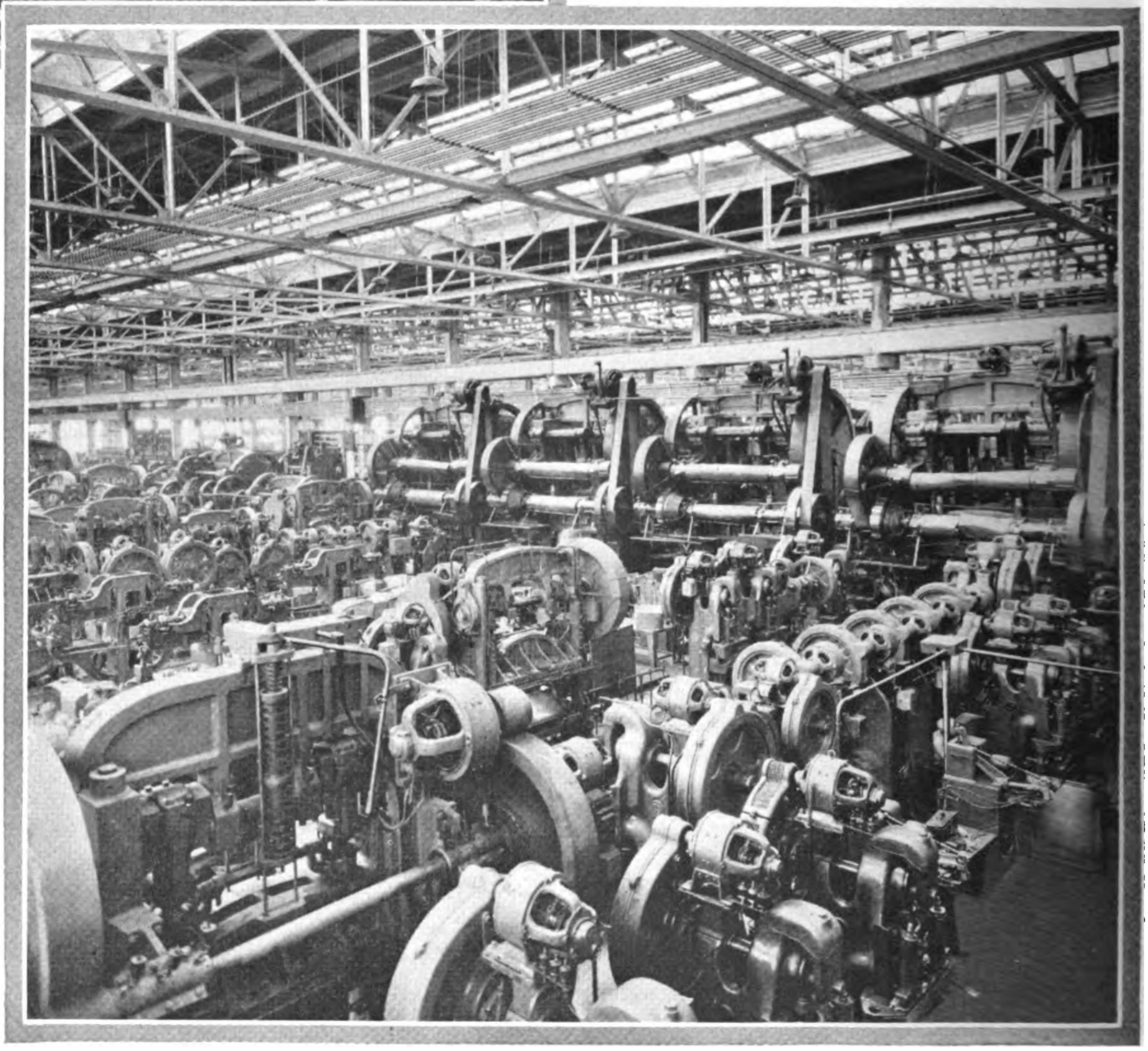
OVERSEA fliers are not hazarding lives for glory only. They are advancing aviation by learning things about airplanes.

The biggest thing they have learned is the importance of little things. Ruth Elder would have gotten all the way across if a small feed pipe had not gone bad.

Take a tip from the fliers. Successful plant operation comes from all of the little things being right.

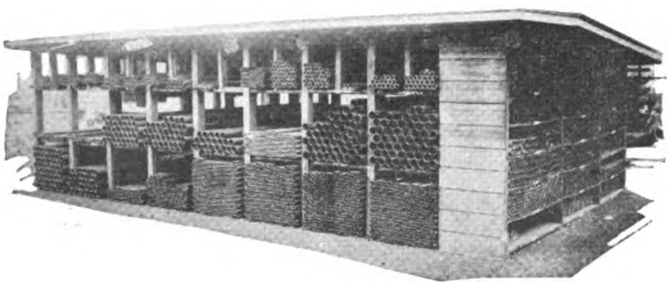
"Old Sol" will help you cut lighting bills and also help the production men to get out more and better work — if you give him a chance. Systematic skylight and window cleaning is a big factor in keeping plants fit for profits.

When the patient can't go to the doctor, the doctor must come to the patient. This portable work bench, on wheels, brings maintenance and repair service close to the machine needing it. It saves time.

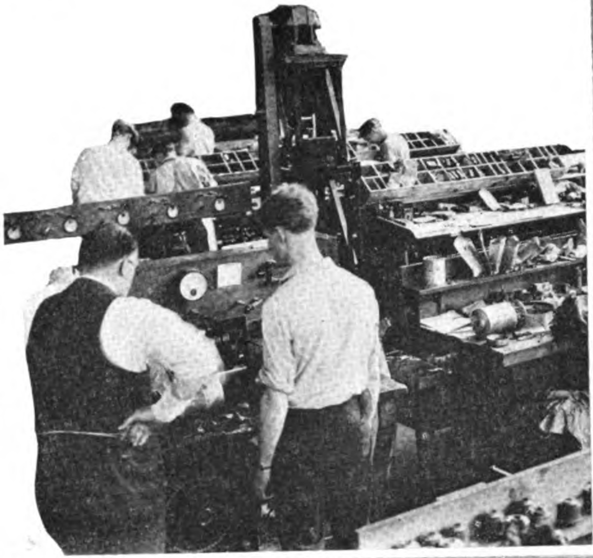


This and the companion picture opposite present in a striking manner, two extremes in power drive practice. Above, we see a one hundred per cent individually motored press and stamping department in the Ford Motor Company's Fordson Works. Note the extremely close machine spacing which is typical of Ford practice.

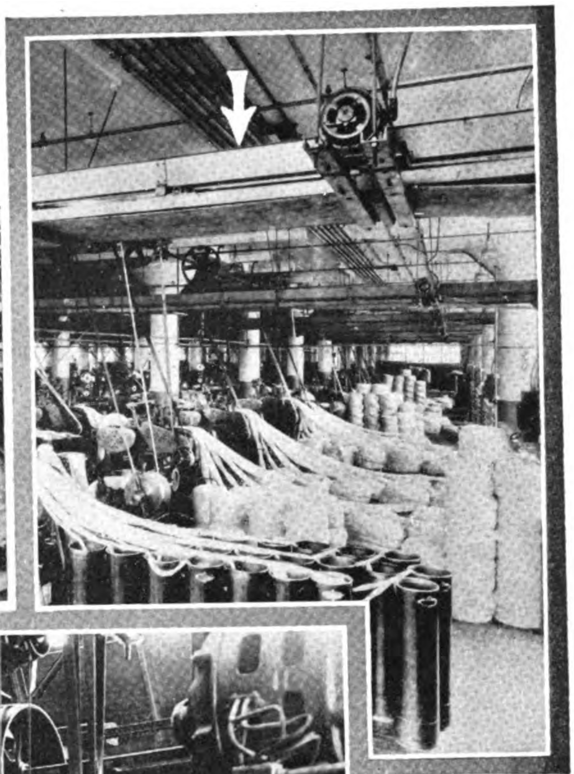
When you see storage facilities like that shown below, you know that the man in charge of materials and supplies is "on to" his job. A sense of order is apparent. This is a "dollars and cents" sense when applied to the services to production.



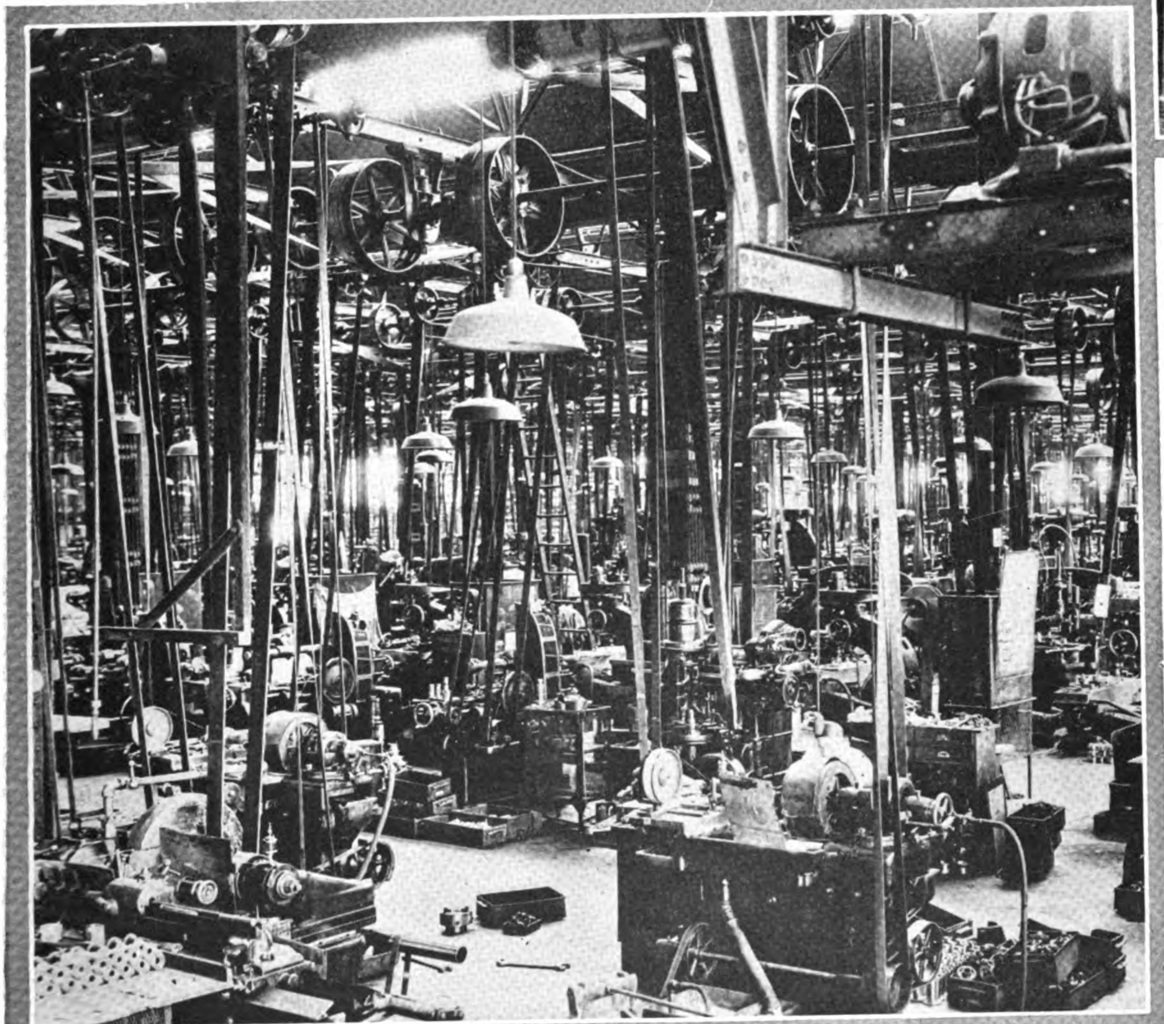
in Pictures



The plant electrician is often called upon to devise electrical product testing apparatus, as well as to maintain it in working order. This is a corner of the American Rolls-Royce Test Department with meters conveniently arranged.

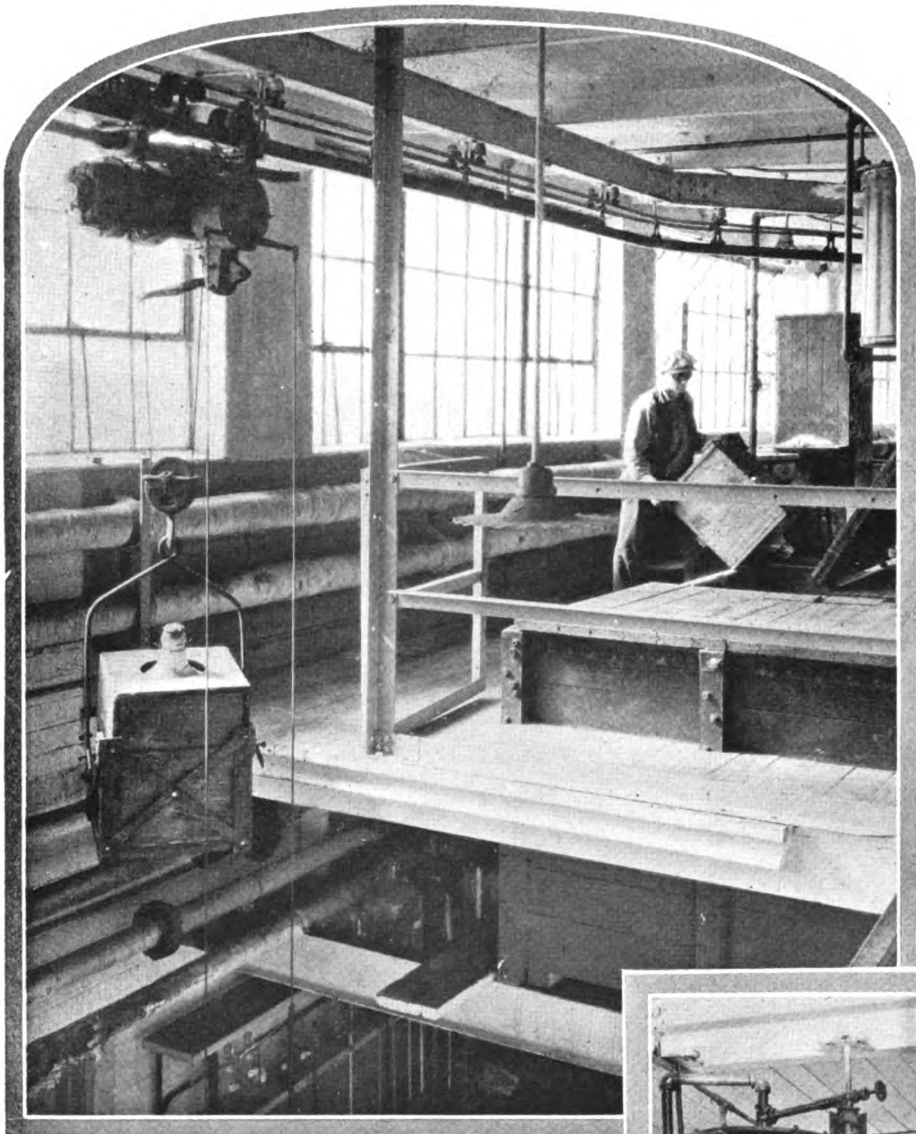


The arrow in the picture above points to a protecting casing which encloses an overhead belt conveyor in the textile works where "Minerva" yarns are made. This enables the belt to run overhead without sag and also prevents spillage of materials.



On this side of the page we have an example of what might be called one hundred per cent belt drive. This is a machine department in the American Rolls-Royce plant at Springfield, Mass. Both the belt and individual motor drive plans have their advantages and limitations as well.

Rapid transit for the service to production. Where plants are extensive in area a motor-cycle and side car enables the maintenance men and tools to get quickly to where the plant engineer wants them.



The operator with the bicycle pump starts the acid running from the carboy into the acid-egg on the floor below.

New Methods of Handling Acids Spell Safety

NEW methods of handling carboys of acid have resulted in far greater safety at the plant of the Industrial Fibre Company, of Cleveland. Formerly it was necessary to lift carboys to the second floor where the operator poured the acid into the mixing tanks.

Later, under the direction of Robert W. Sanborn, safety director, what is known as an "acid egg" was installed under the platform. The carboy is emptied by siphoning into this egg or blow-case. The operator starts the acid running by giving a couple of strokes with the bicycle pump and then it empties itself into the egg, which will hold six carboys. Then the valve is closed and locked so that no other workman can tamper with it. The operator then goes to the second floor and by opening a compressed air valve can blow the acid up into the mixing tank.

Reconditioning

Water-Soaked Electrical Equipment

One to three weeks will generally be required for the drying operation, depending on the size, the voltage, the condition, and the method of drying—

says A. C. Roe

WHEN electrical equipment such as generators, motors, transformers, control switchboards, etc., has been submerged, partly or wholly, or exposed to dampness, it should not be used until tested and either found suitable for use, or cleaned and dried, and in some cases dipped and baked or sprayed with a high-grade, air-drying varnish.

The first caution is: *Do not apply a high-voltage test to any piece of electrical apparatus to determine the condition of its insulation to ground.*

The reason for this statement is that usually the equipment has been operating for a year or more and in many cases would not stand the standard A.I.E.E. high-potential ground and between-phases test of twice operating voltage plus 1,000 volts.

All rotating apparatus should withstand a test of 150 per cent of its rated voltage to ground; between phases the test voltage should not in any case be less than 600 volts.

All distribution transformers of 500 to 5,000 volts should stand 7,500 volts to ground and between high-and low-tension windings, and 3,000 volts between the low-voltage winding and ground.

Small units, such as fractional horsepower motors, current and potential transformers, no-voltage release coils, small induction or d.c. motors, etc., should be baked dry in an oven.

Larger units can be dried out on their own foundations, as will be described later.

When oven-drying the smaller apparatus, the important point to keep in mind is that we are attempting to drive moisture or water from the interior of the parts, and that the process must be carried out by long applications of temperature not exceeding 80 to 85 deg. C.

If the temperature is raised too quickly, or is allowed to exceed 85 deg. C., gas or vapor is likely to be generated at a pressure that will puff or puncture the insulation and make a rewind necessary.

Also, when an oven is used to bake water-soaked equipment, good and constant ventilation must be provided to carry off the vapor. What is more important, the heat of the oven must be regulated so that the hottest spot inside any piece of apparatus being baked does not exceed 85 deg. C., for ordinary insulation such as applied to machines up to and including 4,600 volts.

For 6,600-volt windings the hottest accessible part of the winding should not exceed 75 deg. C., total temperature.

For 11,000- and 13,200-volt windings the maximum total temperature should not exceed 65 deg. C. at the hottest accessible part. The reason for reducing the temperature on the higher voltage windings is because thicker insulation is used and there is a greater distance between the inside of the coil and the outside when the temperature is measured by a thermometer.

There is no absolute method of telling when the insulation is bone dry, but measurements of the insulation resistance to ground with a Megger will give an indication of its condition and provide a guide as to whether the winding should be dried internally, or a high-potential test applied.

Remember that the insulation resistance of any piece of apparatus is greater when cold than when hot. Also, the insulation resistance of large armatures will be proportionately lower than small armatures. This is due to the larger area of insulation on the large machine.

During the drying out run readings of the insulation resistance should be taken at regular intervals and plotted as a curve, using time for the horizontal scale and resistance for the vertical scale. The drying out should continue until the resistance has begun to increase and becomes approximately constant. If the insulation contains appreciable moisture the resistance will decrease during the first part of the drying-out process.

The following quotation is of interest, from the A.I.E.E. Standards 7-551.

"*Minimum Values*—The insulation resistance of the armature of a machine at its operating temperature should not be less than that given by the following formula:

$$\textit{Insulation resistance in megohms} = \frac{\textit{rated voltage}}{\textit{rating in kva.} + 1{,}000}$$

The insulation resistance can be used as a guide for applying a high-potential test, and a safe rule is that the insulation resistance should be approximately 1 megohm for each 10,000 volts applied for testing.

When equipment is too large to be moved, it can be baked by building a box around it and heating by steam coils (steam tight), electric heating units, gas or charcoal in salamanders, providing there is good ventilation in all cases.

If current is available it can be used as follows: Induction motors can be dried out by operating at no-load and low voltage (the current and heating increase as the primary voltage is lowered), or with the motor at a standstill a low voltage can be applied that will allow sufficient current to flow to heat the winding. Alternating or direct current can be used for the stand-still method.

Drying Out D.C. Generators—(1) Drive the generator by its motor or from some external source, and short-circuit the armature beyond the ammeter, using a very weak field excitation. If the generator is shunt wound, low-voltage separate excitation must be employed; if compound wound the armature may be short-circuited through the series field coils.

Direct-current generators are very sensitive when operated as series machines and there is danger of generating an excessive current. Conse-

quently, this method should be used only by experienced operators.

(2) The field coils may be dried by applying from some separate source of excitation approximately two-thirds of the normal direct-current voltage.

There is always danger of serious injury to the windings when drying out with current, as the heat generated in the inner parts is not readily dissipated. Furthermore, coils containing moisture are much more susceptible to injury from overheating than when thoroughly dry. The temperature of all accessible parts should be carefully observed during the drying out process and never allowed to exceed 85 deg. C., total temperature. Several hours or even days may be required for thoroughly drying out large machines.

During the drying-out process the temperature should not be allowed to drop below that of the surrounding air, as moisture then condenses on the coil surfaces and the effect of the previous drying will largely be lost.

In cases where d.c. machines are operating on short-circuit separately excited at a low voltage, excess circulating current can be prevented by shifting the brushes slightly with rotation, or in the case of compound generators, reversing the series field so as to give a bucking action.

Heating windings by current is more effective than any process of heating from the outside, such as enclosing the machine and heating the air by steam coils or a fire.

Synchronous Motors and Generators —These can be dried out by rotating the motor or generator at any convenient speed and short-circuiting the armature beyond the ammeters. The field should be excited so that the desired heating current will flow in the armature winding.

If a low voltage (5 to 15 per cent of normal) can be obtained, the armature winding can be dried out by applying this low voltage to the armature terminals, the rotor remaining stationary. The field winding should be short-circuited and the temperature of the cage-winding on the rotor should be watched. Less than normal current will be necessary on account of the absence of ventilation.

Whenever possible it is highly desirable to dip and bake all stators or armatures and wound rotors in good baking varnish. To obtain the best results the part to be dipped should be heated to approximately 60 deg. C. and allowed to soak in the varnish until all bubbling ceases.

When the apparatus is too large to dip it should be sprayed with a good air-drying varnish, two or more coats being applied, according to the voltage and service.

All exposed surfaces of collector rings, mica V-rings, and riser necks of commutators should be painted with a good insulating compound.

All other exposed parts such as bushings, brush-holders, fiber blocks, etc., should be painted with air-drying varnish suitable for this purpose.

There are three cleaning fluids that can be applied to windings without injurious effect. These are:

(1) Benzine (petroleum naphtha) or gasoline. Both are highly inflammable and their vapors mixed with air are explosive. They should be used only in open places having good ventilation and where fire hazard is small.

(2) Equal parts of carbon tetrachloride and benzine, or 60 per cent carbon tetrachloride and 40 per cent gasoline. Both of these mixtures are non-inflammable, but their vapors mixed with the correct proportions of air are explosive. If ventilation is good they can be used where the fire risk is high.

(3) Carbon tetrachloride is both non-inflammable and non-explosive and can be used under any conditions.

Gasoline and benzine have less corrosive action on insulating varnishes than carbon tetrachloride alone.

The windings should be cleaned as much as possible by scraping or wiping before using any of these liquids.

The rotors of squirrel-cage motors do not have to be bone dry. If the paper cell is not saturated enough to throw off water when in operation they need not be baked, as they will dry out satisfactorily in operation.

All metal parts should be cleaned and painted to prevent corrosion and all bearings opened and drained, the bearing surface cleaned and polished and new oil put in.

Methods of Drying Oil-Insulated Transformers

Treatment of distribution or power transformers presents a slightly different problem, although the remarks pertaining to testing apply. The oil should be tested for water, and if its dielectric strength is low it should be dehydrated by filtering. Where the quantity of oil involved is small it can be discarded and new oil purchased, or it can be collected and filtered using some new oil to service the equipment needed first.

When the oil is removed from the transformer the case and windings should be cleaned and freed of all sludge and scale, before drying out or adding new oil.

There are three methods that may be followed in drying out transformers: (A) by internal heat; (B) by external heat; (C) by internal and external heat.

Drying by Internal Heat—For this method alternating current is required. The transformer should be placed in its case without the oil and the cover left off to allow free circulation of air. The low-tension winding should be short-circuited and sufficient voltage impressed across the high-tension winding to circulate enough current through the coils to maintain the temperature at 75 to 80 deg. C. About one-fifth of normal full-rated current is generally sufficient to do this. The impressed voltage necessary to circulate this current varies within wide limits among different transformers, but will generally be approximately 0.5 per cent to 1½ per cent of normal high-tension voltage at normal frequency.

The end terminals of the winding must be used, not taps, so that current will circulate through the total winding. The amount of current may be controlled by a rheostat in series with the high-voltage winding.

This method of drying out is superficial and slow and should be used only with small transformers, and then only when local conditions prohibit the use of one of the other methods.

Drying Out by External Heat — The transformer should be placed in a wooden box with holes in the top and near the bottom to allow air circulation. The clearance between the sides of the transformer and the box should be small so that most of the heated air will pass up through the ventilating ducts among the coils and not around the sides. The heat should be applied at the bottom of the box.

The best way to obtain the heat is from grid resistors, using either alternating or direct current. The temperature limits are the same as given above. The transformer must be carefully protected against direct radiation from the heaters. It is advisable to line the lower part of the wooden box with asbestos.

Instead of placing the heater inside the box containing the transformer, it may be placed outside and the heat carried into the bottom of the box through a suitable pipe. Where this plan is followed, the heat may be generated by the direct combustion of gas, coal or wood, provided that none of the products of combustion be allowed to enter the box containing the transformer. Heating by combustion is not advocated except when electric current is not available.

This method, while effective, requires a much longer time than the following method, which is generally recommended.

Drying by Internal and External Heat

The transformer should be placed in a box and external heat applied while current is circulated through the windings. The current should, of course, be considerably less than when no external heat is applied.

This method is used occasionally where direct current only is available, a certain amount of current being passed through the high-voltage winding only, as the cross-sectional area of the low-voltage conductor is generally too large for it to be heated with an economical amount of direct current. The use of direct current for drying out is not recommended except where alternating current cannot be obtained.

On the whole this method is quicker than either of the others and has the great advantage that the insulation is heated much more uniformly.

If the initial insulation resistance is measured at ordinary temperatures it may be high, although the insulation is not dry, but as the transformer is heated up it will drop rapidly.

As the drying proceeds at a constant temperature, the insulation resistance

will generally increase gradually until toward the end of the drying period when the increase will become more rapid. Sometimes the resistance will rise and fall through a short range one or more times before reaching a steady high point. This is caused by moisture in the interior parts of the insulation working its way out through the outer portions which were dried at first. As the temperature varies, the insulation resistance also varies greatly; therefore the temperature should be kept nearly constant and the resistance measurements should all be taken at as nearly the same temperature as possible. Measurements should be taken every few hours during the drying period.

A curve of the insulation resistance measurements should be plotted with time as abscissas and resistance as ordinates. By observation the knee of the curve (i.e., the point where the insulation resistance begins to increase more rapidly) can be determined. The total drying period should be about 115 per cent of the time preceding the passing of the knee of the curve.

As the drying temperature approaches the point where fibrous materials deteriorate great care must be taken to see that there are no points where the temperature exceeds 85 deg. C. Several thermometers should be used. They should be placed well in among the coils near the top and screened from air currents. Ventilating ducts offer particularly good places in which to place some of the thermometers. As the temperature rises rapidly at first, the thermometers must be read at intervals of about ½ hour. In order to keep the transformer at a constant temperature for insulation resistance measurements, one thermometer should be placed where it can be read without removing or changing position. The other thermometers should be shifted about until the hottest points are found, and should remain at these points throughout the drying period. Wherever possible the temperature should be checked by the increase-of-resistance method.

When a transformer is being dried out remember that it is soaked with oil and in an inflammable condition. While hot it may be ignited very easily by an arc or flame of any kind. It is well to have a chemical extinguisher or a supply of sand at hand for use in case of fire.

It is not safe to attempt to dry out transformers without giving them constant attention.

Exposed paper or thin fibre parts, etc., will, if subjected to any protracted immersion in water, swell up and become so distorted that they are useless. These parts should be replaced with new ones, for the best results.

Careful inspection should also be made of any untreated wood details, as these are likely to swell or warp, depending on the grade and hardness of wood used and its condition when new.

Careful consideration must be given to the possible presence of water or moisture between the laminations or in the ventilating ducts and the baking or drying out time governed accordingly.

Engineering Committee Adopts Simplified Wrench Stamping

BECAUSE of the recent addition of the new American Standard of bolt and nut sizes necessitating additional combinations of wrench openings, it is no longer feasible to stamp wrenches with all of the various standard bolt and nut sizes, and the symbols heretofore employed.

The principal members of the drop-forged wrench industry have, therefore, seized the present opportune occasion to simplify their stamping practice by stamping wrenches with only the size of opening. Except for disposal of stock on hand, all wrenches shipped hereafter will carry this simplified stamping.

To avoid unnecessary confusion and to educate both mechanics and distributors to the new practice, J. H. Williams & Co., Buffalo, N. Y., has prepared the accompanying table of standard bolt, nut and cap screw sizes served by each wrench opening.

Previously, the custom was to stamp the heads of drop-forged wrenches having fixed openings with the bolt or cap screw size each opening would accommodate. For instance, a wrench with an opening of ⅞ in. would be stamped to indicate that the opening would fit U. S. Standard nuts for ½-in. bolts, hex cap screws of ⅝-in. diameter screw, and S. A. E. Standard cap screws of 9/16-in. diameter screw and nuts for same.

The new American Standard bolt and nut sizes recently adopted would add other markings to the list already carried by the wrench, consequently the American Engineering Standards Committee specified that, wrenches shall be marked with the width across flats of the nut, etc., they are designed to fit.

COMPARATIVE WRENCH SIZES FOR STANDARD BOLT, NUT AND SCREW SIZES

*Wrench Openings as Stamped	U. S. Standard: For U. S. Std. Nuts; Size Bolts	U. S. Standard: For U. S. Hex. Head Cap Screws Diameter Screws	S. A. E. Std. for S. A. E. Std. Nuts and Cap Screws: Size Bolts	American Standard: For American Std. Nuts; Size Bolts	American Standard: For American Std. Hex. Head Cap Screw Dia. Screws
5/16	1/8	1/8			
3/8	....	3/16	....	....	....
13/32	3/16	....	....	....	....
7/16	....	1/4	1/4	1/4	1/4
1/2	1/4	5/16	5/16	....	5/16
9/16	....	3/8	3/8	5/16	3/8
19/32	5/16	....	....	....	....
5/8	....	7/16	7/16	3/8	7/16
11/16	3/8	....	....	....	....
3/4	....	1/2	1/2	7/16	1/2
25/32	7/16	....	....	....	....
13/16	....	9/16	....	1/2	9/16
7/8	1/2	5/8	9/16	9/16	5/8
15/16	....	....	....	5/8	....
31/32	9/16	....	....	....	....
1	....	3/4	11/16	....	3/4
1 1/16	5/8	....	3/4	....	....
1 1/8	....	7/8	....	3/4	7/8
1 1/4	3/4	1	7/8	....	....
1 5/16	....	....	....	7/8	1
1 3/8	....	1 1/8	....	....	....
1 7/16	7/8	....	1	....	....
1 1/2	....	1 1/4	....	1	1 1/8
1 5/8	1	1 3/8	1 1/8	....	....
1 11/16	....	....	....	1 1/8	1 1/4
1 13/16	1 1/8	....	1 1/4	....	....
1 7/8	....	....	....	1 1/4	....
2	1 1/4	....	1 3/8	....	....
2 3/16	1 3/8	....	1 1/2	....	....
2 1/4	....	....	....	1 1/2	....
2 3/8	1 1/2	....	....	....	....
2 9/16	1 5/8	....	....	....	....
2 5/8	....	....	....	1 3/4	....
2 3/4	1 3/4	....	....	....	....
2 15/16	1 7/8	....	....	....	....
3	....	....	....	2	....
3 1/8	2	....	....	....	....
3 3/8	....	....	....	2 1/4	....
3 1/2	2 1/4	....	....	....	....
3 3/4	....	....	....	2 1/2	....
3 7/8	2 1/2	....	....	....	....
4 1/8	....	....	....	2 3/4	....
4 1/4	2 3/4	....	....	....	....
4 1/2	....	....	....	3	....
4 5/8	3	....	....	....	....
5	3 1/4	....	....	....	....
5 3/8	3 1/2	....	....	....	....
5 3/4	3 3/4	....	....	....	....
6 1/8	4	....	....	....	....
6 7/8	4 1/2	....	....	....	....
7 5/8	5	....	....	....	....

*Proper clearance is provided by the manufacturer.

What a Flood Means to the Plant Engineer

(Continued from page 554)

height varying from 14 to 20 in. on the ground floors. The tunnels were, of course, completely filled, thus cutting off all light, heat, and power. Most of the power is generated locally. The boilers are oil-fired, but the boiler room was flooded and the oil burners entirely submerged.

A connection was made with an emergency power line from the local utility, so that lights could be obtained in the power house. However, the big problem was to get the water out of the tunnels. No motor-driven pumps were available, but a 1,500-g.p.m. turbine-driven, centrifugal pump is used for the condensers. It was eventually decided to use this pump to empty the tunnels. The question of steam supply was settled by driving the yard switch engine alongside the power house and running a steam line from the boiler to pump turbine. An 8-in. suction line from the pump was put into one of the tunnels, and in a comparatively few hours this tunnel was empty. The discharge was carried through the lines leading to the cooling pond and emptied into a sewer in the street.

The three tunnels are separated by low walls; so it was necessary to pump each one out in turn.

Drying the Conduit Lines

By the time the tunnels were empty the water had receded so that the boilers could again be fired. The next step was to dry out the conduit lines in the tunnels. To remove the feeders, which range from 4/0 to 300,000 circ.mil in size, would have been a difficult task; so it was decided to try other means.

Previous experience had shown that after submersion, trouble is most likely to occur at splices. Accordingly these were untaped. Then compressed air lines were run into one end of the conduits and sealed in as well as could be. The compressed air effectively removed the water and much of the mud and sediment. The air was kept on for about three days and the tunnels heated to a temperature of between 80 and 85 deg. F. Provisions were made to secure as much ventilation as possible. Megger readings were taken on the lines at fairly frequent intervals and when these reached what was considered to be a satisfactory value, the splices were retaped and power turned on. After a week of operation no trouble had been experienced with any line.

A total of 45 squirrel-cage motors and one slip-ring motor were submerged for two or three days. These motors range in size from 3 to 20 hp. They were taken apart as quickly as possible, cleaned and dried out in an oven at 150 deg. F. for two to four days. At the end of this period they were given a Megger test. Motors that gave a reading of 40,000 ohms or above were put back in service, although several soon failed. A number of other motors either gave a low Megger reading or failed during the subsequent running test at line voltage; so a total of 16 motors were sent to a local repair shop for rewinding.

Directions for the treatment of electrical equipment that has been submerged are given on page 585.

Under emergency conditions that affected a wide area and in which the physical strength and loyalty of plant men were severely tested through long days and nights of constant struggle and danger, many heroic deeds were performed. One of the most dramatic battles was waged at the United Electric Light Co., Springfield, Mass., in its struggle to maintain power and lighting service in the stricken city.

The older portion of the station is built close to the river's edge and when the water rose nearly 24 ft. above normal level a critical situation ensued. Construction work was in progress and when the flood came, a large hole that had been cut in the wall for the installation of new cables was hastily plugged and further protected by a rough cofferdam. Within a few hours the old walls were submerged to a depth of about 15 ft. by a raging torrent that swirled around them with almost irresistible force.

The basement of the old building is a veritable maze of vaults and passageways. Here a force of men varying from 40 to 60 in number staged a grim battle against the forces of nature, and eventually won out. Working 15 ft. below the level of the river and protected only by old masonry walls of unknown but doubtful strength, these men were in imminent danger of sudden death at any moment. If the old walls had failed there would have been little or no chance for anyone to escape. Fully realizing the situation, these men, nevertheless, worked for three days and nights strengthening the walls with thousands of sandbags, plugging leaks where the water rushed in, and hastily putting every available pump to work in a desperate effort to keep the water from rising high enough to put the station out of commission.

In the end, high courage and utter disregard of danger and fatigue saved the day, and service was maintained without interruption.

Less dramatic but no less strenuous efforts were made in hundreds of plants to save equipment and raw materials or finished products from damage, when basements and even ground floors were flooded in some of the higher sections of the city.

In a paper mill more than a million pounds of stock was moved within a few hours from the basement to a safe storage place in another plant. Gas and electric trucks, hand trucks, wheelbarrows—every available means of transporting material were employed to move the stock, and it was all taken out in time to avoid damage.

How Other Plants Managed

At North Adams, Mass., more than a hundred feet of one wall of a large textile mill on the banks of the Hoosic River collapsed when the swollen river undermined the foundation. This mill is rushed with orders, so a temporary wooden wall was erected on each floor. Equipment that was flooded was hastily cleaned out or replaced, and production went on with little interruption.

In a large worsted mill part of the wall of a small brick structure housing the fire pumps was washed away, allowing the flood waters to flow through the storerooms in the basement of one of the main buildings. When the water went down more than a foot of mud, bricks, and rubbish of every description was left behind. Part of this has been removed, but weeks will be required to take all of it away.

Similar stories could be told about hundreds of plants in the flooded area. When disaster came the plant forces met it coolly and bravely, doing everything that was humanly possible to prevent or minimize damage to equipment and material. In many cases, they succeeded wonderfully well. When the odds were against them and their plants were engulfed, these men set to work with undaunted courage and clear heads to repair the damage and get the wheels of industry turning again just as quickly as possible.

Limitations of

SILENT CHAIN DRIVES

that affect the design and service for many transmission purposes

[The application of silent chain drive has solved many transmission problems, but it has not been the solution of all transmission trouble.]

By A. B. Wray

Chief Engineer, Morse Chain Co. Ithaca, N. Y.

IT IS DIFFICULT for one who has been associated with the development of silent chain drive for nearly twenty-five years to realize that silent chain driving is still in its infancy. As compared with belting, gearing, and perhaps other forms of power transmission equipment, it is a veritable youngster.

When the silent chain drive was first introduced, it was considered chiefly as a possible drive where belting or gearing seemed impractical. Today its application is extensive and it has solved many transmission problems.

The commercial use of the silent chain has extended over a period of some thirty years. In the early days, the design of each of these drives was a strictly engineering proposition based on the special requirements. The art of chain driving as we have it today has been built up from the knowledge obtained by designing drives for definite requirements as to horsepower, speeds, center distances, service, etc.

The average engineer feels perfectly able to select what he considers a proper belt drive or gear drive for his particular service. These methods of power transmission have been used so many years that information as to theory of operation and capacity has been well developed and very complete engineering data are available in every handbook and treatise on power transmission.

The silent chain manufacturer has now come to the point when he too must disseminate data so that engineers can properly select their own drive. Also, he must try to put his engineering data in such form that they will be easily understood and as readily used as the data on gearing and belting. First, however, must come a more adequate understanding by prospective users of the general limits of application.

The manufacturers of silent chain drives do not claim that their drives should be used for all transmission purposes, or that they are the solution of all transmission troubles.

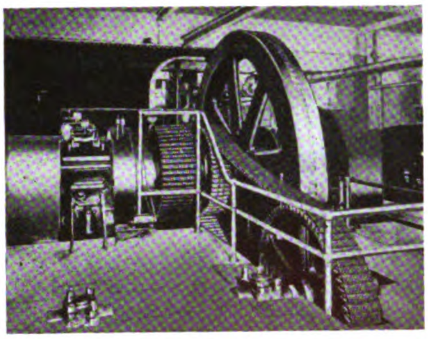
There are limitations as to design and service and a general knowledge of these will be helpful to all concerned.

Horsepower — The largest power transmitted by silent chain drive in a single strand of chain is 1,000 horsepower, but by the use of multiple strands a 5,000-hp. generator is being driven from two water turbines. The smallest drive is transmitting small fractions of a horsepower, a complete drive weighing only a few ounces.

Speeds—The smaller pitch chains will transmit small horsepowers at speeds of over 6,000 r.p.m. Some of the large pitches are not capable of running over 250 r.p.m. Each pitch (the chain manufacturer figures his chains and sprocket by circular pitch), is suitable for certain speeds. The drive will be noisy if running above its rated speed. It is customary to use the largest pitch the speed will allow, as this keeps the cost of the drive to a minimum.

Ratios—For ordinary service best results will be obtained by keeping the ratio less than 8 to 1; however, there are many cases where large ratios are being successfully handled. It is often cheaper to go to a double-reduction drive than to handle an extremely large ratio in a single drive. An excessively large sprocket is unwieldy. A more compact installation is obtained with a double reduction. The drive is equally satisfactory with a speed-up or reduction. On a speed-up drive, it is customary not to try to handle as large speed ratios.

Center Distances — Long centers should be avoided with silent chain drives. In fact, with excessive long centers the price of the drive is often prohibitive. The advantage of this drive is that it enables two shafts to be placed on a minimum center distance, thus making a compact, neat installation. The minimum center distance for a certain pitch is a function of the speed ratio. It is best practice to have the opening angle made by the two strands of chain less than 35 deg., unless the tight strand of chain is on the bottom; then it is possible to increase the open angle as each sprocket is wrapped more than half way by the chain. Sometimes it is preferable on an extremely short-center drive to run the tight strand of chain on the top. On a large ratio the tight strand chain should usually be run on the bottom.



WHERE THE CENTER DISTANCE WAS TOO GREAT FOR A GEAR DRIVE

These silent chains transmit 2,000 hp. in driving 22 rubber mills and 6 calenders. End play is provided for, by holding the sprocket in alignment and allowing the shaft with a feather key to slide through the hub.

Sprocket Teeth—It is seldom advisable to use less than 13 teeth in a pinion. On rare occasions sprockets with as few as 11 teeth have been used. It is seldom advisable to use sprockets with more than 135 teeth, although there are many cases where considerably larger sprockets have been used. The chain speed usually determines the size of the sprocket. It is perfectly possible to run the chain speed up to 1,400 ft. a minute, and a chain speed of 1,600 or 1,700 ft. a minute is often good practice.

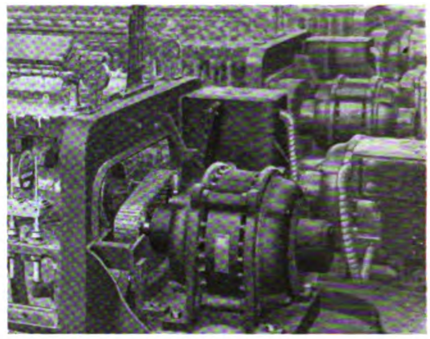
Chain Width—Roughly speaking the maximum chain width is about twelve times the pitch; however, by the use of a multiple-strand drive very much larger powers can be transmitted. The 5,000-hp. drive referred to above was handled by eight strands of chain, each strand 2 in. pitch, 20 in. wide. Two-strand drives are very common, and occasionally drives with more than two strands have been installed and successfully operated.

Noise—If a chain of a certain pitch is over-speeded it becomes more noisy. By the same token, if a pitch is under-speeded, it becomes more quiet. There are certain cases where noise is objectionable in which a smaller pitch than is indicated by the rotative speed should be used.

There are certain classes of service that the silent chain manufacturer investigates very carefully before applying the drive. Among them are compressors and engines. Are the fly wheels on these machines heavy enough to give uniform rotation during a single revolution? If not, the chain will whip and the whip may be disastrous. Of course, on multiple cylinder machines there is less tendency for the chain to whip and the balance wheels provided on the machines are usually heavy enough to give very uniform rotation. The single cylinder machines are the ones with which to be particularly careful. Other reciprocating machines should be examined critically, such as metal planers, slotters, flat-bed printing presses, etc. The silent chain manufacturer does, however, make a spring sprocket which can be used to advantage on this type of machinery.

Excessive end play in shafts has to be provided for. When the movement of the shafts is considerable, it is usually possible to hold the sprocket stationary and allow the shaft to slide through with a feather key.

A number of years ago a certain rubber mill was making plans for enlarging the plant. It was desired to install a 2,000-hp. engine midway between two line shafts, which drove 22 rubber mills and 6 calenders. The center distance was much too short for a belt drive. To use rope drive



OIL WAS A DETERRENT TO THESE DRIVES WHEN BELTS WERE USED

Alteration in the product is prevented by the elimination of slippage.

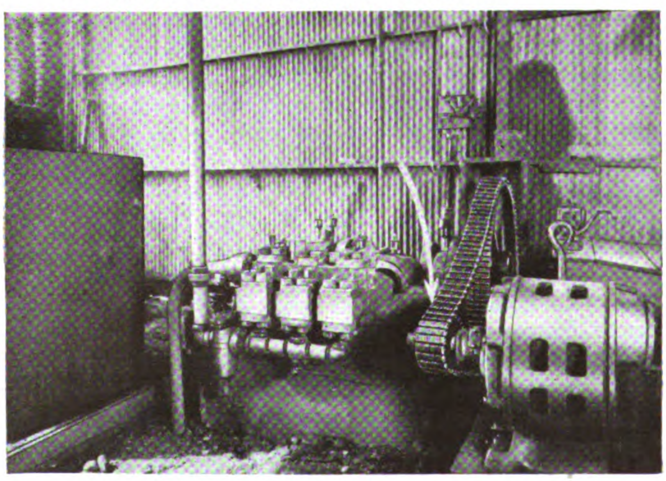
would have necessitated remodeling the upper stories of the mill to provide a tightener carriage. The center distances were too long for gear drives. Had gears been used it would have necessitated a train of three gears. These would prove troublesome and noisy. They knew they could obtain an efficiency of 98½ per cent with silent chain drives. The installation was made some 18 years ago and is still running successfully.

When the magnetic clutch with solenoid brake first came on the market, a question arose in the minds of some engineers as to whether the silent chain could stand the strain which would come from the sudden stopping of the machinery, through throwing the clutch and immediately stopping the driver shaft. A good many of these magnetic clutches have been installed and the difficulties that these engineers feared have never been realized.

Many engineers prefer chain drives to gears for this service. If for any reason lubrication of the gears is

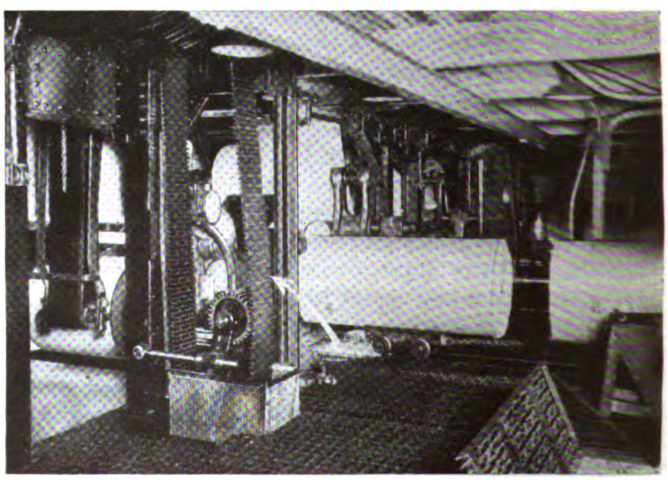
FIVE YEARS SERVICE WITHOUT AN HOUR'S DELAY

The Penn Forge Company eliminated press production delays due to gear breakage with this silent chain installation on its high-pressure pump.



WHERE EDITIONS MUST BE RUN OUT ON TIME

A vertical silent chain having an adjustable idler drives the presses in a mid-western newspaper plant. Heretofore, vertical drives were to be avoided.



neglected for a short time, they are ruined and it entails having duplicates on hand, and the cost of taking out the old and installing new ones. With a chain this would not be likely because a chain can go days without lubrication attention and without serious damage. If the chain was spoiled the sprockets themselves would be uninjured. In fact, it is impossible to break the chain gears, on account of the number of teeth engaged. The chain might indeed break, but that would occur only if not in alignment, or if bought too light for the work. If a chain is to be removed for wear or for any other reason, it is only a matter of a few hours to put one on and the cost of a reserve chain is very small as compared to a set of gears.

Installation Economies

Some think that chain drives take up a good deal of room but it is not so. Take for example a 250-hp. motor, the center distance can probably be between 5 and 6 ft. The motor can be set on the floor level driving down to the line shaft at an angle. This reduces the apparent amount of room required and saves the deep excavation required by gears as practiced by some.

The silent chain manufacturer has always considered a vertical drive as one to be avoided. If a vertical drive is necessary some method must be provided either to adjust the center distance or take care of the slack in the chain, which develops from wear. This can often be accomplished with an idler. If an idler cannot be conveniently installed, the chain can be shortened as wear develops, ordinarily two links at a time, but with the use of a hunting link, one link at a time. A very interesting installation is on large newspaper presses. These presses came equipped with vertical shaft and gear drive, but for eighteen months the excessive friction made it a constant uphill fight to keep the presses running and the editions put out on time. Maintenance costs were very high.

A 100-hp., chain drive was installed connecting the driver shaft running 325 r.p.m. to the driven shaft running 300 r.p.m. on 128-in. centers; these shafts were directly, one above the other. The adoption of this chain drive eliminated three sets of gears in each drive or a total of six gears. In spite of the terrific speed at which the chain must work, the operation was much smoother and practically noiseless. The chain used less than 5 per cent as much oil and grease for lubrication, eliminated one man and materially reduced current consumption.

Roller Bearings on Conveyors

(Continued from page 577)

been developed, two typical examples being shown in Figs. 10 and 11. The wheels are usually of the dead-axle type. The cups are usually given a press fit in the wheel hub, and the cones a metal to metal fit on the axle. One very simple method is shown in Fig. 10, in which the cups are installed in the usual manner, and the cones are properly set up on a sleeve. The whole comprises a unit assembly of wheel and bearings. The unit is properly located by the conveyor links. Both the outer and inner closures are made up of labyrinth washers. The assembly shown in Fig. 11, is different in that it is somewhat more complicated; (cones are fitted directly on the shaft) and in that it does not permit of unit assembly such as that illustrated in the preceding figure.

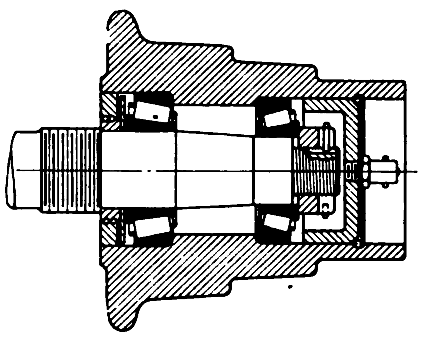


FIG. 12—TYPICAL BEARING MOUNTING FOR PALLET WHEELS OF SLAG CONVEYORS

The bearing cups on both sides are pressed against shoulders machined in the wheel hub. The cones are given a light fit on the shaft.

It will be noted in both cases that the entire space between the bearings is available as a reservoir for lubricant, which is inserted through a hole bored in the hub of the wheel. Because of this arrangement a supply of lubricant sufficient to last for some time without necessity of renewal is permanently insured.

Another type of installation which somewhat resembles that made to the conveyor wheels just described, but which is interesting because of the exceptionally severe service requirements are the pallet wheels of slag conveyors used in steel mills. In this instance not only are the bearings subjected to heavy thrust and radial loads, but to relatively high temperatures as well. The latter condition naturally tends to make proper lubrication of the bearings rather more of a problem than is usually the case. A typical example of such an installation is shown in Fig. 12. The bearing cups on both sides are pressed against shoulders machined in the wheel hub, and the cones are given a light fit on the shaft. The closures are of very simple, but of very effective construction, and are so designed as to completely prevent not only the leakage of the lubricant, but the entrance of foreign matter under all conditions of heat. The lubricant is supplied through counter-bored holes in the shaft, and the space between the bearings is utilized as a reservoir. The whole assembly is characterized by its strength and simplicity.

Reinforcing Welded Joints to Increase Strength

Unless the work has been very carefully done, a weld in heavily stressed parts is likely to be of less strength than was the original material. To compensate for this diminution in strength of the broken part, in addition to amply filling around the joint, some method of reinforcing the welded joint is often adopted.

To reinforce a break in a solid bar, a sleeve may be placed over the break and welded at both ends. This method is employed where the joint in the rod is stressed by either a pull or by a bending force.

An inner sleeve may be used in tubing, to reinforce a welded joint. This method of repair will suffice where the joint is subjected to either a bending or a tensile stress.

Plate welds which are as strong as the plate are difficult to make. The best way of making a very strong joint is to use butt straps. Holes are punched in the strap, and the welding is done both at the break and at the holes in the reinforcing straps. When properly made, such a joint is very satisfactory and makes a continuous weld across the plate unnecessary.

These methods of reinforcing welds not only represent years of study by a large plant specializing in shop and ship repairs, but they have proved their effectiveness, for some of the joints have been tested under actual working conditions in the same plant where they were made.

George A. Luers.
Washington, D. C.

QUESTIONS Asked and Answered By Readers

HERE IS A PLACE *where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.* Practical Pete

QUESTIONS
Who Can Answer These?

Location of Elevator Motors

Due to alterations in one of our four story buildings, the location of the two present elevators is to be changed. But before the new electric elevators are installed, we wish to have readers advise us of the advantages of elevators equipped with overhead motors as compared with motors located at the foot of elevator shafts.

Portland, Ore. S. B. V.

Resistance of Coils Delta Connected

We are experiencing difficulty with a piece of equipment that has three coils connected in delta. After a study of the operation of the equipment, it seems as if the resistance of the coil in one phase must be different than the others. These three coils are sealed in such a way that only the leads, which are tapped to the interconnecting points of the coils, are available. It would, therefore, be to our advantage in several ways if we knew how to determine the resistance of each coil from data obtained by measuring the resistance between the three main phase connections.

Los Angeles, Cal. R. W. D.

Heating of Armature After Rewinding

After rewinding a d.c. lap-wound armature having 24 slots, 2 coils, and 40 turns of No. 26 wire, the 48 segments became very hot after running only a very short time, although the number of wires and number of turns are the same as before. The coils in the slots are wound with a pitch of 1-and-12, and the connection leads with a pitch of 1-and-12. The brushes are located in the center with the poles. The first coil is wound clockwise on one side of the shaft, and the second coil is wound on the other side of the shaft, all leads being brought forward in the same direction. It seems that if the first and second coils are not spread with the shaft between them, there is no trouble; but with this style of armature a better job can be made by having them split. Would I have to change the lead of the second coil, the reverse to No. 1 coil, by taking the leads of the second coil back 12 slots instead of forward, as in coil No. 1?

Toronto, Canada. F. A. E.

Can the Speed of this Motor be Changed Without Rewinding?

We have a Type ITC, Form M, 720-r.p.m., three-phase, 10-pole, 60-cycle, G.E., slipring motor with approximately 120 rotor slots and 90 stator slots, the intermittant duty horse power being 22. The rotor in this case is bar wound with end connections. As we wish to increase the speed of this motor without rewinding it, will readers kindly tell me how to reconnect the motor?

Seattle, Wash. W. M. P.

How Many Machines in a Group?

We are planning on moving about 100 machines, all practically alike, into an extension to the plant. At present these are driven as a single group by a 100-hp. motor belted to a main lineshaft extending down the center of the plant. The individual countershafts are either belted to this mainshaft or to one of the two parallel shafts which also extend the full length of the building and are belted, one on each side of the mainshaft. We believe that it would be advantageous to break up this drive into smaller groups. Our opinions on size of groups vary from 10 to 25 machines per group. It is agreed that the motor used should rate at 1 hp. per machine. Would other readers please give us their opinions or experience on relative cost and advantages of using groups of these various sizes.

Philadelphia, Pa. B. W.

Selection of Pulleys and Belts

When selecting pulleys and belts, should serious consideration be given to the coefficient of friction between a particular type of pulley and a certain kind of belt? Also, when operating belts at a speed of 6,000 ft. per minute, will a special treatment or construction of the face of the pulley result in a greater coefficient of friction?

Lowell, Mass. K. M. S.

Cleaning Switchboards

Our switchboards are operated continuously day and night, with the result that they must be cleaned and cared for while in operation. As we have experienced some difficulty in caring for them will readers tell me how they clean boards operating under conditions similar to ours? Also, should Duco or some other paint or preparation be applied, and, if so, how?

Utica, N. Y. L. W. J.

Compound Winding of D.C. Generators

We are desirous of learning the number of turns needed for a flat compound winding of a 125-volt d.c. generator and also a 250-volt generator. So will readers kindly furnish me with a formula, which is suitable for ordinary repair shop practice, for determining the desired number of turns.

Chicago, Ill. W. H. K.

ANSWERS *Received to Questions Asked*

Maximum Economical Size of Motor for Group Drives

We have a number of group drives operating screw machines, lathes, and so on, the driving motors ranging between 20 and 40 hp. Installation of new machines will make it necessary to replace two 40-hp. induction motors with larger ones, or to split these two drives into smaller groups. I understand that some plants will not use a motor in excess of 35-hp. rating on a group drive, the group being split up when the power required exceeds this figure. I wish that some readers would let me know what their policy is on this point, and tell me how they determine the maximum economical size of motors for group drives. That is, when should a group drive be split up instead of installing a larger motor to take care of increased power demand?
Moline, Ill. W. B.

IN ANSWER to the question by W. B., the problem of limiting the size of motors used for group drives and the application of motors to individual machines must be considered in a manner similar to many other engineering problems—namely, by determining which method is the most economical financially.

To properly study the desirabilities of certain motor applications, a number of factors must be considered, the value or importance of each depending upon the existing conditions or those that are likely to exist in the future. Among the important factors to be considered are the following:

1. Investment in building material necessary to accommodate the weight of the line shafts, hangers, pulleys, and the like.
2. Overhead shafting, belts, and pulleys will require more head room than unit drives and may interfere with the diffusion of natural light. Also, there may be a greater risk of physical injury with this type of drive due to mechanical breakage or to belting.
3. Cost of maintenance including lubrication and repairs.
4. Speed regulation and loss of production in the event of a burnout, breaking of belts, or other accidents that may stop an entire group of machines for long periods and involve extensive repairs.

Speed regulation has an important influence on the quality of the product and must be given careful consideration. It is usually wise to consider overtime conditions in which only a small part of a group may be necessary.

Constant or fluctuating loads must receive due consideration or further losses that are hard to calculate may be encountered. For intermittent loads or loads requiring a variable speed, individual drives are the proper ones to employ. In the case of W. B.'s drive, which I judge is in a machine shop, a group drive is not efficient. However, the greater installation cost of individual drives in many cases may not warrant the required investment, all factors considered, from a financial standpoint.

So, if W. B. cannot change to individual drives due to financial limitations or for other reasons, he should split the drive into smaller groups rather than replace the present drives with larger motors. B. W. SCOTT.

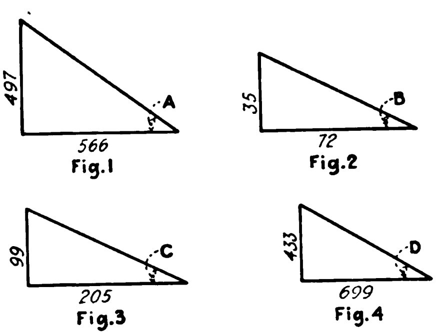
Assistant to Electrical Engineer,
American Woolen Co.,
Andover, Mass.

Loading Synchronous Motor to Improve Plant Power Factor

The total load on our plant is 566 kw., at 75 per cent lagging power factor when a three-phase, 440-volt, synchronous motor is pulling 105 amp., from the line, with the excitation adjusted for 90 per cent leading power factor. Will some reader tell me what the plant power factor will be if the synchronous motor load is increased to 300 amp., and the excitation adjusted for 90 per cent leading power factor at this load?
Cleveland, Ohio. B. E.

IN ANSWER to the question by B. E., the power factor of the system, after the load on the synchronous motor has been increased so that it uses 300 amp., may be determined as follows:

Fig. 1 represents the components of the total load when the synchronous motor is drawing 105 amp. Since the power factor of the line is 75 per cent, angle $A = 41$ deg. 20 min. The total reactive component is, therefore, $566 \times \tan 41$ deg. 20 min. $= 497$.



THE PRINCIPAL STEPS USED IN DETERMINING THE NEW POWER FACTOR OF THE SYSTEM

The load taken by the three-phase synchronous motor is $105 \times 440 \times \sqrt{3} = 80$ kva. At 90 per cent power factor, angle B in Fig. 2 = 25 deg. 50 min. The active component = $80 \times \cos B = 72$ kw., and the reactive component = $80 \times \sin B = 35$ kva.

The difference betwen the components of the total load and of the synchronous motor load must be the components of the remaining load (lagging). Without the synchronous motor the active component = $566 - 72 = 494$ kw., the reactive component = $497 + 35 = 532$ kva. and the power factor is 68 per cent.

If the synchronous motor is to draw 300 amp., 440 volts, at 90 per cent power factor leading, the load taken by the motor will be $300 \times 400 \times \sqrt{3} = 228$ kva. In Fig. 3 angle $C = 25$ deg. 50 min. Now the active component = $228 \times \cos B = 205$ kw., and the reactive component = $228 \times \sin B = 99$ kva.

When this leading load, Fig. 3, is added to the lagging load found by adding algebraically the components in Fig. 4, active kilowatts = $494 + 205 = 699$, and the reactive kilovolt-amperage = $532 - 99 = 433$. As the tangent of angle $D = 0.619$, the angle $D = 31$ deg. 45 min. Since $\cos D = 0.85$, the new power factor will be 85 per cent.

Paterson, N. J. NICHOLAS COOK.

IN ANSWER to B. E.'s question, the final plant power factor would be 0.85, as found by the following calculations:

From the 566-kw. load, the kilovolt-ampere load is found by dividing the kilowatt load by the power factor; thus, $566 \div 0.75 - 755$ kva. The reactive kilovolt-amperage = $\sqrt{755^2 - 566^2} = 499.6$, which is lagging, due to the fact there is a lagging power factor in the system.

As the load on the synchronous motor is to be increased, the difference between the present and the proposed amperage load = $300 - 105 = 195$ amp. Then the added kilovolt-ampere load = $\sqrt{3} \times 195 \times 440 \div 1{,}000 = 148.5$. The corresponding kilowatt load = 148.5×0.90 (0.90 is the power factor of the motor) = 133.7 kw. The reactive kilovolt-amperage = $\sqrt{148.5^2 - 133.7^2} = 64.6$. The reactive kilovolt-amperage of the synchronous motor in this case is leading and in direct opposition to the lagging reactive kilovolt-amperage of the load. Combining these results with those previously obtained, we find that the total kilowatt load has increased to 699.7, the lagging reactive kilovolt-amperage has decreased to 435, and the kilovolt-amperage load has increased to 832.9. Since the power factor is equal to the actual power divided by the apparent power, we have $699.7 \div 823.9 = 0.85$ lagging. So 85 per cent is the final plant power factor.

J. Y. SHIRLEY.

Engineering Department,
Kelly-Springfield Tire Co.,
Cumberland, Md.

IN ANSWER to the question by B. E., the plant load under the conditions as given is as follows: load = 566 kw.; power factor is 75 per cent lagging, total kilovolt-amperage = —755, and the reactive kilovolt-amperage = —498.

The kilowatt capacity of the syn-

chronous motor while drawing 105 amp. when the power factor is 90 per cent is 72, and the total kilovolt-amperage and the reactive kilovolt-amperage are 80 and 34.8 respectively.

The new plant load conditions without the synchronous motor operating will be: $566 - 72 = 494$ kw.; $\sqrt{494^2 + 532.8^2} = 729$ and the reactive kilovolt-amperes $= -498 + (-) 34.8 = -532.8$.

The new motor load will have the following characteristics: Total kilovolt-amperage $= 300$ amp. $\times$ 440 volts $\times \sqrt{3} = 228$; the total kilowatt load $= 228 \times 0.9$ (lead) $= 205$; and the reactive kilovolt-amperage $= 228 \times 0.435 = 99.2$. The total load on the plant will then be $494 + 205 = 699$ kw. or $-532.8 + 99.2 = 433.6$ kva.

The tangent of the angle the cosine of which represents the power factor desired may be found by dividing 433.6 by 699. This angle may be found by referring to a trigonometric table. The cosine of this angle is 0.85. So the power factor of the line when the synchronous motor is drawing 300 amp. is 85 per cent, and the total kilovolt-amperage is 0.822.

C. O. VON DANNENBERG.
Electrical Division,
General Engineering & Management Corporation,
New York, N. Y.

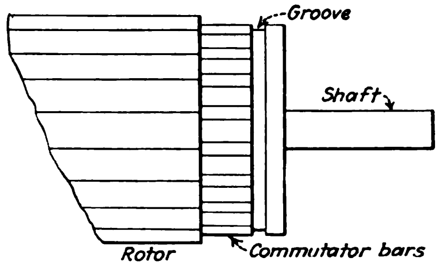
Fastening Rotor Bars to End Rings

The heating of the rotor in one of our squirrel-cage induction motors during the starting period affects the soldered connections between the cars and the rings enough to make it necessary to resolder these connections about every 6 months. Will readers tell me how to solder or secure the bars permanently to the rings so as to eliminate further trouble with them? If silver solder, or some other kind, is employed, I should like to know what flux to use, together with any suggestions you can give me on how to do the job.
St. Marys, Ont., Canada. W. E.

SILVER solder, as mentioned in the question by W. E., can be used to securely fasten the bars to the end rings in which case borax should be used as a flux. However, a much more substantial job can be made if the bars are welded to the rings. This welding may be done by the acetylene or an electric method. H. E. STAFFORD.
Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Canada.

IN REPLY to the question by W. E., I have found it very good practice to use acetylene welding to secure rotor bars to the end rings with a good grade of brass or bronze.

In the larger sized rotors, I make a practice of machining a groove $\frac{3}{4}$ in. wide by $\frac{1}{2}$ in. deep (depending on the cross section of the ring) in the end of the rings next to the bars to a depth that is equal to about one-half the depth



A GROOVE CUT IN END OF RINGS NEXT TO ROTOR BARS ALLOWS AMPLE CONTACT SURFACE BETWEEN THE SOLDER AND THE ROTOR BARS

of the bars, as shown in the accompanying illustration. After this groove is filled by means of acetylene welding, a very permanent connection results. After the welding process is completed, the rotor is placed in a lathe and the surplus metal is machined off.
Youngstown, Ohio. V. J. WINKLE.

Changing Single-phase Motor for Three-phase Operation

I have a 2-hp. single-phase, 110/220-volt, 1,725-r.p.m., 60-cycle, repulsion-reduction motor that I wish to operate on a three-phase supply. I do not want to rewind the rotor if I can help it, but should like, if possible, to increase the horsepower rating, keeping the speed the same as before. The motor drives a lineshaft from which we operate a small lathe, a drill press and an emery wheel. What will I have to do to this rotor to change it for three-phase operation? When the motor is operated three-phase, will the starting torque be greater or less than it was on single-phase operation?
Farmland, Ind. A. G. B.

IN ANSWER to A.G.B.'s question, it probably would not be necessary to rewind the rotor in order to change to the three-phase operation.

When a single-phase motor is changed to three-phase for the same speed, the horsepower is usually increased automatically. I believe, however, that a squirrel-cage winding would be more suitable in this case. If a squirrel-cage winding is desired, it should be about 80 per cent of the weight of the stator coils when the material is of cast copper, and of cast brass, it should be about three times the weight of the coils. This weight, of course, includes the end rings and the bars in the slots.

A short time ago I rewound a small single-phase machine for three-phase operation. A copper wire band was wound around the commutator under a few pounds of tension. Two copper clips were used under the band, and when the band was finished, it was soldered as is customary with any ordinary banding job.

If the commutator had been of the centrifugal switch type, we would have had to solder a copper circle around the bars. In a case of this kind the switch should be removed.

The motor was rewound for three-phase, four-pole operation, but we found out later that a six-pole motor would have been more satisfactory because of lack of room in the end bells. This made it difficult to place the coils in the stator slots.

GRADY H. EMERSON.
Birmingham, Ala.

Driving Lineshaft By Two Motors

Several machines are operated from one lineshaft in our mill. On some days the load on this shaft is 15 hp. while on others it is 50 hp. We have two 25-hp., constant-speed, shunt-wound motors on hand, and wish to connect them to the shaft through clutches. When the load falls below 25 hp., one motor can be shut down. Will readers tell me (1) whether these motors will operate properly if connected to the same shaft? (2) Is this plan feasible? (3) Is it possible to operate in this manner two constant-speed compound-wound motors, two series motors, or two adjustable-speed, shunt motors?
McKeesport, Pa. E. K.

REPLYING to the question by E. K., the plan of driving the line shaft with two 25-hp. constant-speed shunt-wound motors through clutches, will prove satisfactory providing both motors have the same speed characteristics, and the pulley dimensions are the same. Also, this arrangement of the motors will prove more economical than using one large motor to drive the machinery.

I would not recommend the use of adjustable-speed shunt motors or a compound motor for this installation.

GUY H. WINTERSTEEN.
Cleveland, Ohio.

IN ANSWER to the question by E. K., two shunt-wound motors when connected to the load and operated from the same supply circuit, as described in the question, will divide the load between them in proportion to their capacities provided their speed characteristics are identical. So, if the motors have the same rating, each will carry half the load.

I do not believe that it is practical to operate adjustable-speed motors in the manner suggested in the question.
Ampere, N. J. N. G. WILLEN.

ANSWERING the question by E. K., it may be best in this case to disconnect the shaft and make two group drives instead of having one drive driven by two motors. Some years ago I tried to operate one shaft with two motors and the results obtained were very unsatisfactory. Even if the motors do take their proportionate part of the load, whenever trouble is experienced with one motor, the other motor is then overloaded.

J. T. Slocomb Co., JOHN J. LYNCH.
Providence, R. I.

Mechanical Maintenance of
POWER DRIVES

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Using a Variable-Speed Unit to Select Best Operating Speed

PLANTS that do a considerable amount of experimental and development work on new products or processes frequently find it difficult to determine the proper operating speed for the machine when ready for actual production operations to begin.

This problem was solved in one Mid-Western plant engaged in the manufacture of a special raw material used in a wide variety of industries by the installation of a Reeves variable-speed unit.

This unit is used in the experimental and laboratory departments, to assist in determining the proper operating speed during the experimental work, and also for establishing operating speeds for the equipment in actual production.

With this particular type of drive laboratory men are able to vary the speed quickly and easily over a large range and study the effect upon the product and on the output. After the most satisfactory speed is determined in the laboratory the machinery for actual production is connected accordingly.

Before the use of this device it was often necessary to make a number of pulley changes, each of which usually meant a change in belt length, before an approximately satisfactory operating speed was obtained. It was impossible to obtain close adjustments in operating speeds by the old cut-and-try method of adjustment.

This process slowed up the experimental work considerably, and even then the speed determined as a result of the tests was only an approximation.

Chicago, Ill. E. G. H.

Short Center Drive Prevents Pulley Wear Due to Slip of Dusty Belt

BELTS which operate under very dusty conditions must be maintained under sufficient tension or have a large enough arc of contact on the small pulley to prevent slippage; otherwise the dusty belt will cause excessive wear on the pulley faces. The action is similar in this case to an endless abrasive polishing belt.

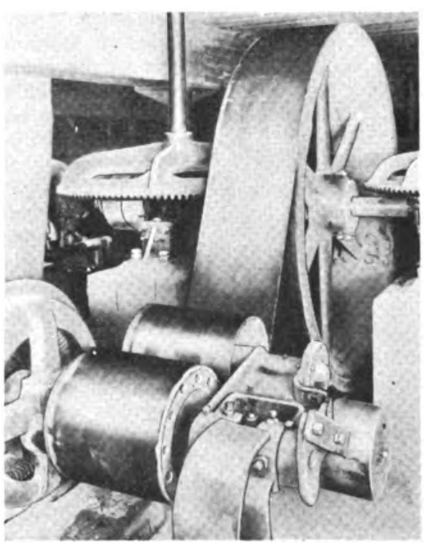
One of the common methods of overcoming this slippage is to use the gravity idler in preference to a high belt tension. In addition, the belt selected must be pliable, tough and have sufficient strength to withstand particularly hard service for a belt.

The accompanying illustration shows a 14-in. double Wabeco (Warren Belting Co.) leather belt installed under very dusty conditions in a hard drive at the plant of the G. F. Wright Steel & Wire Co., Worcester, Mass. This drive has been operating satisfactorily over the Pulmax (Bird Machine Co.) gravity idler for a number of years with an average amount of attention.

Also, a composition pulley is used on the motor to further help reduce the slippage. With the high reduction ratio and short centers, as may be seen from the illustration, an extremely flexible belt is necessary.

When purchasing a belt for any type of hard drive and particularly where much of the severe service is due to the surrounding conditions, such as dust which cannot be prevented, it is especially necessary to consider quality, because life and probable maintenance cost are of paramount importance to assure a low annual belt cost.

HIGH-REDUCTION RATIO DRIVE UNDER DUSTY CONDITIONS IN WIRE MILL



Local Conditions Determine Lubrication Policies and Practices

LUBRICATION policies and practices for various machines in an industrial plant are sometimes determined by the local conditions rather than by the rules generally followed. On ball bearings in textile mills, for example, it is often preferable to use grease instead of oil. This is because there is less likelihood of leakage than with oil. Also, a mixture of lint, fluff, and other material of this kind, with oil, is highly inflammable.

There is always the risk of oil falling on the fabric and it is practically impossible to remove mineral oil stains from fabric without damaging it. One of the lubrication practices often followed is to apply a mixture of animal, vegetable and mineral oil in cases where oil must be used, because a stain resulting from such a mixture can be removed. Another lubricant, which is sometimes used in such cases, is a mixture of sperm and castor oils, in equal proportions; this has proved to be an efficient lubricant and its stain can also be removed.

Lubrication of the spinning machine spindles is important because sometimes as much as 15 per cent of the power used in the spinning department may be friction loss resulting from bad lubrication; proper lubrication, therefore, offers opportunities for substantial economies here. Because of the high speed and small clearance between the spindle and the bolster, a light oil is essential.

Where there is any doubt about the oil used. a test can be made on a machine driven by an individual motor or, if this is not available, on a small group of machines. It is necessary first, however, to correct any unsatisfactory operating conditions of the machines. Each of the oils chosen should be tested for at least a week. Particular attention should be given to the temperatures of the bearings in operation with each oil and meter readings taken of the power consumption at the end of the week. Better results may be obtained by the use of graphic meters. It will probably be found that the amount of power used with different grades of oil will vary considerably. The oil which shows the lowest power consumption should be used provided that the spindles do not overheat. While making these tests it is absolutely necessary that the work done on the machines should be fairly constant, otherwise such a test would be useless.

Brentford, England. W. E. WARNER.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Reconditioning of Direct-Current Commutators

ALTHOUGH commutators are often subjected to much abuse, such as being allowed to become oil soaked, to have flat spots and grooves, and to be fitted with brushes of improper characteristics, yet the life of a commutator averages from one to three armature windings.

When a commutator requires new mica segments or needs refilling, the old segments should be checked with a micrometer and replaced with new segments of the proper thickness. If this is not done, trouble may be experienced in tightening the commutator when reassembling.

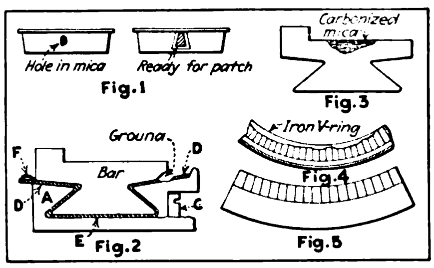
The insulating segments between the bars are of amber mica in a built up form and range in thickness from 0.015 in. to about 0.045 in., the thickness depending upon the diameter of the commutator and the voltage between the bars, which is seldom over 30 volts, the average being about 15.

The Canada amber mica used for segments is made in built up sheets, and the binder used is shellac or some kind of gum. These sheets, which are about 18 in. x 36 in., can be obtained in various thicknesses. Consequently the average repair shop would require only three or four thicknesses. The segment mica is usually marked with a label of a different color than that used on molding mica. Also it is lighter in color than the molding mica but does not mold; and if heated it will disintegrate.

If only a few mica segments are charred or defective, Fig. 3 in the accompanying illustration, the V-ring may be removed and one commutator bar unsoldered for a pattern. The defective mica can then be scraped out with a sharp hook-like tool made of an old hacksaw blade. After this is done, the cavity may be filled with patented commutator compounds, with powdered mica and shellac, or shellac and plaster of paris. The mica segment in the rough should be about 1/16 in. longer and wider than the commutator segment in order to furnish sufficient stock.

When a small hole has been burned through a mica segment, the small holes can be patched by removing the clamping ring. Then the mica should be cut out as shown in Fig. 1. The patch is made of two pieces of mica. The one on the bottom next to the iron ring is made smaller than the top patch, a 1/4 to 3/8 in. margin being allowed. These pieces, which are made of molding mica, are tapered toward the outside, for by so doing they are prevented from being backed out as pressure is applied when tightening the commutator. After the mica has been shaped to the ring curvature, it should preferably be shellacked in place with orange shellac, which is clean, free from lumps, reasonably thick, has a small amount of rosin dissolved in it, and made up with gum and alcohol, for the prepared shellac is usually too thin for this purpose.

Fig. 2 shows the usual method of insulating a commutator bar and also the place where most grounds occur. The cylinder *E* is not used in all commutators, but it is an added safety factor. The cord band shown at *F* should be used on both ends of the assembly and



WHERE COMMUTATOR MICA GENERALLY GIVES TROUBLE

it is a good idea to paint it with shellac, for this resists moisture better than paint.

With traction motors, cranes, railway and mining machinery, grounds through the V-ring insulator often occur. This insulator, which is made of molding mica, is made to conform to the shape of the clamping rings by molding while hot. The mica varies in thickness but the average is from 0.045 in. to 0.070 in.

Figs. 4 and 5 show the method of cutting a ring to form one layer of the V-insulator. After a pattern is made from the V-ring out of heavy paper, enough stock is added to this to make the complete V. Warm the mica with a torch before forming around the ring, and where the ring laps, it should be beveled about an inch. In this case the shellac is applied to both surfaces of the mica. Wire or cord is then wrapped or twisted around the mica, which is warmed until it fits the ring perfectly. Apply sufficient heat to drive out all surplus shellac and to stick the mica to the ring. Then the scalloped portion is bent down and formed all the way around the ring, and when this operation is completed the bars and mica are sandpapered. After the high spots are trimmed down with a wood chisel or sharp knife, the other layer is applied. Make the joint of the second layer correspond with that of the first one. Now the whole ring can be refinished and be made ready for assembly. It is always advisable to use two or more layers of mica in the forming of a new ring insulator, for this insures a perfect insulation if the joints are staggered.

This inside scalloped portion may be made by pressing down on the mica with a babbitt form, which has been made in the ring itself, or the forming may be completed by clamping the ring.

As a ring cannot be made in one piece on large commutators, they are made up of a number of separate pieces with the joints staggered. In this case the commutator may be heated with a torch, being careful not to overheat the comutator assembly. After tightening the assembly, the winding is installed, but before soldering the commutator, tighten the bolts or nuts again.

While soldering the risers it is a good plan to work them up tight. If the risers clamp well, they may be soldered on the side of the armature. When soldering large commutators they should be heated with a torch as the iron is applied; the work will be speeded up in this way. Burnley's soldering paste is almost universally used in preference to flux solder on commutator work. The surplus paste should be removed with gasoline or alcohol after the job is finished and before painting. For large d.c. machines, a 6- to 10-lb. iron is used, a slot being drawn in the point of the iron to help distribute the heat. On deep soldered commutator bars the armature should be tilted so as to prevent the solder from running back of the bars and causing short circuits.

After the soldering operation and while the commutator is still warm, tighten the bolts again if possible. When the armature is taken from the baking oven, the bolts should again be inspected for tightness.

If a bar should rise in operation, it should be carefully tapped down and the commutator tightened. Then it should be turned, filed or ground with a stone, and finished with fine sandpaper. There is a general impression that all commutators should be milled, but this is not the case, for milling depends on its proposed service, the mica segments and the hardness of the brush.

GRADY H. EMERSON.
Birmingham, Ala.

New Equipment

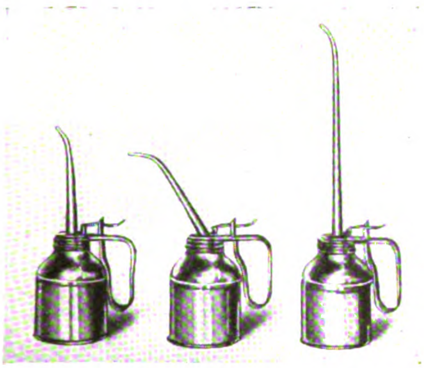
For Plant Operation and Maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Positive Pump Oiler

THE production of a line of positive pump oilers, three types of which are shown in an accompanying illustration, have been announced by the Plews Oiler Co., 405 Boston Block, Minneapolis, Minn. This oiler is made in six styles and in sizes ranging from ¾ pint to 1 quart in capacity. It is said to pump light or heavy oil in warm or cold weather, and will exert a pressure at the spout of 100 lb. per sq. inch.

The cans are made of steel, copper plated. The pump action is controlled by a thumb lever mounted on top of the handle. According to the manufacturer, the pump action is by telescoping tubes with ball valves in the bottom of both the movable and the stationary tube. Upward movement of the outside sleeve forces oil into the upper chamber, which is constantly filled with oil by reason of the ball check valve. The position of the outside movable tube is such that the container may be practically empty before the container pump will cease working. The quantity pumped is controllable.



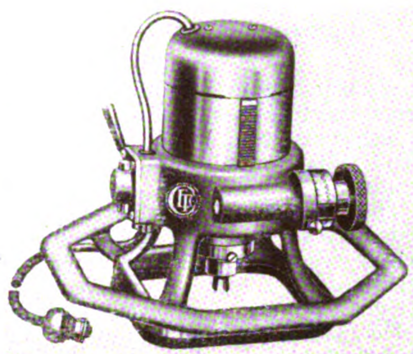
Three Types of Plews Positive-Pump Oiler

Light-Weight Router

RECENT advances in the desigu of universal type motors prompted the Cincinnati Electrical Tool Co., Cincinnati, Ohio, to design its router.

In its construction ball bearings are used and the method of direct drive is also claimed as a feature. To prevent the entrance of dirt or grit and the escape of lubricant, felt washers, which are protected by metal retaining rings, are employed.

The adjustment stop on this machine is graduated to 1/16th, and a turn of the stop-pin release allows the router to move freely in the slideway for the full length of its travel. A knurled hand wheel, operating through a rack and pinion, provides a rapid and positive method of lowering the cutter into the work. This method of control, it is claimed, is ideal for cutting rosettes, fluting, boring, and the like.



Cincinnati ¾-hp. Router

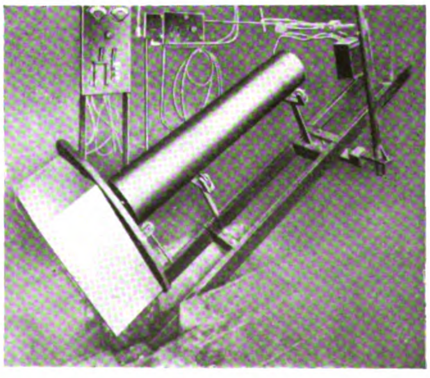
This machine is sturdily constructed and weighs 30 lb. The ¾-hp. motor operates at a speed of 12,500 r.p.m., thus making possible, it is claimed, a clean and finished cut. This router can be furnished wound for 110 or 220 volts, for operation from either a lamp socket or power line.

Automatic Tank Welder

A NEW carbon arc, automatic welding machine has recently been put on the market by the Lincoln Electric Co., Cleveland, Ohio. This machine is designed primarily for the purpose of welding the heads in range boilers.

The rotating table is driven by a small variable-speed motor that provides speed adjustments for tanks of various diameters. Roller rests are also provided, which maintain the alignment of the work. The carbon electrode is carried by an adjustable arm supported from a rigid pedestal on which the motor starter is mounted. No filler metal is required in this operation; the head being flanged and inserted so that a lap joint is secured as in a riveted tank. The heat of the arc, the manufacturer claims, melts the edge of the lap weld of the cylindrical sheets, fusing it with the head and forming a solid, leak proof joint.

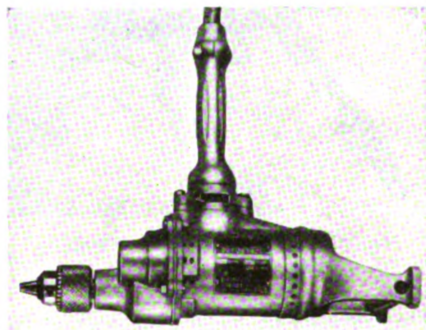
Lincoln Electric Automatic Welder for Range Boilers



On 14-gage material, seams have been welded at the rate of 135 ft. per hour, it is claimed. While these machines were developed primarily for welding range boilers, they are equally applicable for welding all kinds of small cylindrical tanks.

High-Frequency Electric Tools

A NEW line of Thor high-frequency electric tools, with squirrel-cage motors operating on 180-cycle current, have been developed by the Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill. The type of motor employed in these tools eliminates armature windings, commutators, and brushes, which are said to have been the seat of trouble in universal-motor tools. The Thor rotor has solid copper bars, riveted and welded in position. The gears are made of special high-grade steel to withstand severe service. The stator case and gear case are of heavy aluminum.



Thor High-Frequency Electric Drill

One of the important features claimed for this new line of tools is their constant speed from no load to peak load. It is stated that there is no slip in speed under load with these tools as compared with universal motor tools. Another important feature is the size and weight, which are said to be about one-third of those of a tool operating on 60-cycle current. This results in easier handling by the workman, thus assuring increased production.

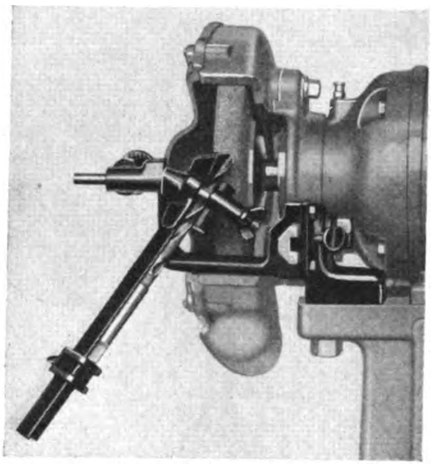
To use high-frequency tools it is necessary to install a frequency changer to step up the frequency of the current to 180 cycles. However, according to

the manufacturer, the advantages are such that any shop having ten or more portable tools in use will find it both profitable and practical to make the change.

The tool illustrated is a ½-in. high-frequency drill, weighing 10¼ lb. and operating at 650 r.p.m. The Thor line of 180-cycle induction-type motor electric tools is composed of drills, reamers, screwdrivers, tappers, nut setters, grinders, and sanders.

Twist Drill Grinding Attachment

THE twist drill grinder illustrated has been brought out recently by the Hisey-Wolf Machine Co., Cincinnati, Ohio. This attachment, according to the manufacturer, is a complete, self-contained unit doubling the utility of the grinder on which it is used, as it affords the dual advantages of two distinct machines. The complete unit is interchangeable with the standard tool grinding rest on Hisey grinders, and can be quickly mounted in position.



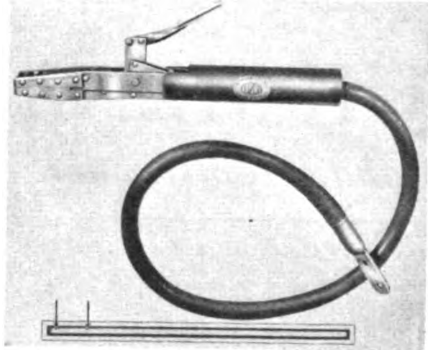
Hisey Twist Drill Grinder Fitted to 10-in. Wheel

This attachment enables the operator to grind twist drills more accurately and also quicker than the old and obsolete free-hand method. It eliminates the use of gages; a graduated micrometer screw adjustment insures identical lip lengths.

A 60-grit grinding wheel of medium grade is recommended and should be dressed frequently so as to retain a straight face. The attachment can be used to grind straight- or taper-shank twist drills from ¼ to 1¼ in. in diameter.

Electrode Holder

THE Fuzon electrode holder for metallic and arc-welding electrodes of all classes, particularly surfaced electrodes, has been designed by the Fuzon Welding Corp., 103d St. and Torrence Ave., Chicago, Ill. The holder, which is shown here, is said to minimize overheating of the electrode and to give perfect contact under any and all conditions. When the electrode is placed in the holder, the jaws clamp and the electrode is automatically pushed forward. This



Fuzon Electrode Holder

movement scrapes all surface materials from the four points of contact, it is stated, thus insuring the welder of a good contact and eliminating overheating.

The electrode stub ends are readily removed and new electrodes easily inserted. Spattered weld metal will not stick to the holder jaw. The device weighs 2 lb. and 3 ft. of extra flexible cable and a connecting lug are included with each holder.

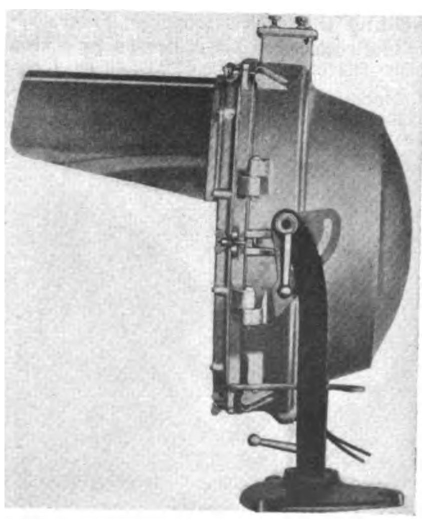
Floodlight Projector

A NEW 24-in. floodlight projector, known as the type SCA-24, has been developed by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., particularly for railroad yard lighting and similar applications where long throw and high beam candlepower are essential.

The large diameter of the reflector in the new floodlight permits, it is claimed, a wide angle of light with high overall efficiency, and its long focal distance gives good beam concentration for long range work.

The 24-in. parabolic chromium-plated brass reflector is mounted in a cast aluminum alloy frame with a spun sheet aluminum back. The lens, of heat-resisting glass, is held in a door, which opens from the front swinging sideways. Thus, it is possible to renew lamps and

Westinghouse SCA-24 Floodlight Projector



clean the reflector without interference from the door.

The floodlight is mounted so that it can be tilted upward where its position is such that approach from the front is not practical. A stop is provided so that it is unnecessary to aim the projector each time it is moved from position. Focal adjustment is provided by three screws, which operate independently, two for "in" and "out" and lateral motion of the lamp, and one for adjustment of focal distance.

The reflector is entirely inclosed, no ventilation being required. It is furnished with either narrow or wide beam projector and with either a plain or spread lens. The visor is supplied as an accessory.

Combination Buffer and Disk Grinder

ANOTHER addition to the line of new and redesigned electrical tools manufactured by the Standard Electrical Tool Co., Cincinnati, Ohio, is shown

Standard Electrical Tool Co. 2-hp. Combination Buffer and Grinder

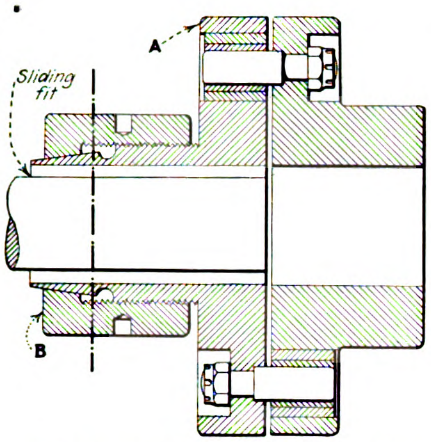
in the accompanying illustration. This combination buffer and disk grinder is made in four sizes rated at ½, 1, 2 and 3 hp. respectively.

The armature shaft is made of nickel steel and is fitted with three SKF ball bearings which are incased in dust-proof casings. A push-button control is mounted on the pedestal within convenient reach of the operator. The steel disk is 12 in. in diameter and is reversible. The 7x14-in. disk table has both horizontal and vertical adjustment.

Flexible Coupling

A TYPE of tension-sleeve coupling designed to facilitate quick changes in direct-connected drive or to permit using one motor to drive different machines at different times is a recent development of the Ajax Flexible Coupling Co., Westfield, N. Y.

The coupling, which is a modification of the Ajax rubber-bumper coupling, is designed so that the flange *A* attached to the driven shaft is readily removable. This flange is made with an extended split hub having a taper on the outside



Ajax Tension-Sleeve Flexible Coupling

and a straight threaded portion as shown. A collar *B* is made to fit over the threaded hub and when screwed up to a tension fit, tightens the hub to the shaft, the hub being further held in place by setscrews fitted over two sliding keys.

The removable flange *A* and collar *B* are of steel, and the other parts are identical with the standard couplings made by this company and are therefore interchangeable in case of accidental breakage. The coupling flanges are connected by means of special bolts and rubber bushings.

Portable Single Unit Blower

A PORTABLE blower known as the "Coppus Heat Killer" has been put on the market by the Coppus Engineering Corporation, Worcester, Mass., for the purpose of reducing the effect of heat radiation on workmen.

The blower, which is mounted on three legs, normally stands 4 ft. from the floor. By means of an adjustable connection the blower can be moved to a vertical angle, in order to direct the air blast to that zone that is desired to be cooled.

Coppus Engineering Corporation Portable "Heat Killer" Blower

These portable blowers are furnished in two sizes; namely, No. 175, which weighs 118 lb., and is fitted with a $\frac{1}{2}$-hp. universal motor adaptable for either 110 or 220 volts, and the No. 250, which weighs 265 lb., is fitted with a 1-hp. motor that can be furnished for operation on a.c. or d.c. lines with voltages ranging from 110 to 550.

Light-Duty Tier Tructor

A NEW, light-duty, 2-ton, electric tiering tructor has been added to the Mill-Type Series of the Elwell-Parker Electric Co., Cleveland, Ohio. This machine, as illustrated, is designed to handle skid loads, as in regular power-lift truck service, or to elevate the load 4 to 8 ft. from the floor when tiering or stacking in storage, or stockroom, or delivering goods to motor truck or to railroad car from rail level to car floor.

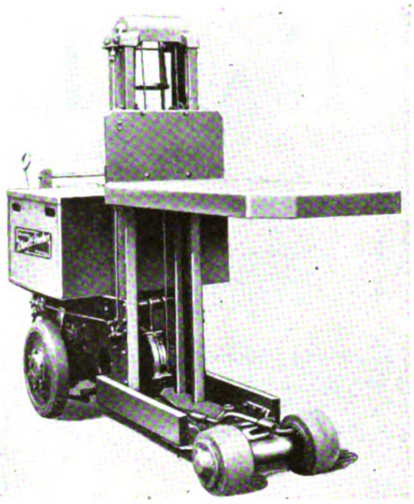
The new machine is of all-steel construction and built on the interchangeable-parts basis. The power plant is of the unit type, with inclosed Elwell-Parker motor, steel brake-drum, steel multi-thread worm-to-bronze differential, chrome-vanadium drive shafts, and universal joints to permit steering and to deliver power to the steel clutch plates bolted to the outside of the drive wheels, which are fitted with solid rubber tires and Timken tapered bearings. The third point support of the power plant is a ball beneath the drive motor.

The operator's pedals, one for the brake, the other for the controller reverse drum, which trip to off-position when pedal is raised, are constructed with a heel rest and non-slip surface, and are spring folded when operator leaves truck. The braking and power application is separate to provide for incline operation. Elwell-Parker heavy-duty, drum-type controller is also used on this machine. All fingers are fitted with reversible tips and the controller contacts are automatically lubricated by a special attachment. The removable controller handle returns to the off-position when released.

The lift controller, located beneath the driving motor controller, is also of the drum type. An automatic trip returns the drum to the off-position when the load platform reaches its highest or lowest point or it can be returned to off-position manually at the will of the operator.

The lift is effected by means of a standard Elwell-Parker, inclosed-type motor with spur-gear reduction to double-grooved drums carrying steel cable which runs over sheaves at top of the uprights to sheaves on elevator carriage to cable equalizer. Cable tension is maintained automatically.

The main frame is built of angles, channels and heavy gusset plates with flanged edges riveted into a rigid box frame. The steering mechanism is of



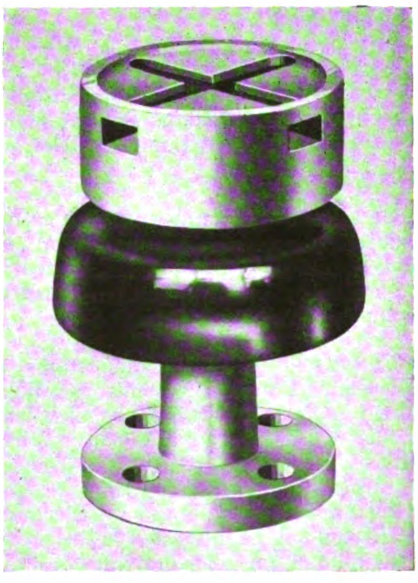
Ellwell-Parker 2-Ton Tiering Tructor

the ball and socket type and steering is effected by means of an adjustable horizontal lever, fitted with a push button connected to high grade electric horn. The entire unit is Alemite lubricated. The trial axle has 10x6-in. tires and tapered Timken bearings.

4,500-Volt Insulator

DEVELOPMENT of a new outdoor bus support for 4,500-volt service is announced by the Line Material Co., South Milwaukee, Wis. This unit is designed and constructed for use with any of the high-tension equipment manufactured by this company. It is interchangeable, in that any of the seven types of clamps may be fitted upon the cap and the unit can be mounted on any type of base. The cap and pin are of malleable iron cemented on to the brown-glazed, wet-process insulator. Both the pin and cap are hot-dip galvanized.

4,500-Volt Insulator for Outdoor Bus Supports. Manufactured by the Line Material Company



Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Transfer Switches—Form 56 describes and illustrates the Sundh automatic transfer switch for changing a load from one source of supply to another.—Sundh Electric Company, Inc., 5 Avenue C, Newark, N. J.

Chain Hoists—Bulletin 21 describes the new Ideal spur-geared ball-bearing chain hoist.—The Dickerman Hoist Manufacturing Company, 872 East 72nd St., Cleveland, Ohio.

Reflectors—Abolite reflectors for every industrial lighting need. Write for Catalog 179, which gives full information on industrial lighting requirements.—National Screw & Manufacturing Company, 2500 East 71st St., Cleveland, Ohio.

Electric Heaters—Bulletins describing complete electric portable and stationary heaters and electric strip heaters.—The Martindale Electric Company, 1252 West 3rd St., Cleveland, Ohio.

Transformers — Bulletin 1027 announces the new type three-phase autotransformer.—Sorgel Electric Company, 91 West Water St., Milwaukee, Wis.

Motors—The new Wagner split-phase motor, type 58 RDT, is completely described in Bulletin 153.—Wagner Electric Corporation, St. Louis, Mo.

Fire Extinguisher—A folder announces the new Phomene Accumulator designed for automatic foam fire protection.—Pyrene Manufacturing Company, Newark, N. J.

Unit Heaters — Form 6818 completely describes the Venturafin installation in the new Oakland-Pontiac plant. —American Blower Company, Detroit, Mich.

Silencers—A number of interesting industrial applications of Maxim silencers are described and illustrated in a new bulletin.—The Maxim Silencer Company, Hartford, Conn.

Conveyors—Various applications of Cleveland Tramrail systems are illustrated in Form TR-563.—The Cleveland Crane & Engineering Company, Wickliffe, Ohio.

Scale Drawing Folio — Electrical draftsmen will be interested in the seven-page folio giving scale drawings of high-tension equipment. These engineering sheets give scales of 1/8 in., 3/16 in., 1/4 in., 3/8 in., 1/2 in., 3/4 in., and 1 in. to the foot.—Delta-Star Electric Company, 2400 Block, Fulton St., Chicago, Ill.

Insulators—"Lead Tip Steel Pins for Insulators" is the title of a new booklet recently issued.—Ohio Brass Company, Mansfield, Ohio.

Compressors—Folder GEA-233A describes GE centrifugal single-stage air compressors with a volume range of from 250 to 75,000 cu.ft. per minute. —General Electric Company, Schenectady, N. Y.

Shock Absorbers—A new general bulletin recently issued describes the Ajax industrial absorber. This book is complete with illustrations and data.—The Ajax Flexible Coupling Company, Westfield, N. Y.

Gears and Speed Reducers—Catalog 123 has recently been issued completely describing James generated continuous-tooth, herringbone gears and reducers.—D. O. James Manufacturing Company, 1120 West Monroe St., Chicago, Ill.

Cable—A folder has been issued describing Wireflex non-metallic sheathed cable with "Wimo" slick finish.—The Wiremold Company, Hartford, Conn.

Electrical Equipment — Catalog 110 sets forth a complete line of railway and industrial electrical equipment manufactured by this company.—The Pyle-National Company, 1334-1358 North Kostner Ave., Chicago, Ill.

Meters—Bulletin W-821 contains an interesting pictorial visit to the Worthington meter factory at Harrison, N. J.—Worthington Pump & Machinery Corporation, 115 Broadway, New York, N. Y.

Motor Starters — General advantages claimed for the use of Allen-Bradley starters for alternating-current motors are discussed in a folder.—Allen-Bradley Company, 491 Clinton St., Milwaukee, Wis.

Fire Extinguishers — Advantages claimed for Fyre-Freez, which uses carbon dioxide liquefied under pressure as the extinguishing agent, are explained in a folder. This gas when released freezes into a dry carbonic snow with temperature of 110 deg. below zero. Fyre-Freez, it is said, can be used on electrical fires and also is effective on gasoline, oil, paint, varnish, lacquer, and carbon bisulphide fires.—Fyre-Freez Corporation, 17 West 46th St., New York, N. Y.

Lift Trucks — A series of folders illustrates applications and gives specification of the Blue Streak side-lift and the Model K heavy-duty Stuebing-Cowan hand-lift trucks and steel-bound platforms.—The Stuebing-Cowan Company, Cincinnati, Ohio.

Safety Ladder — Features of the construction of the Dayton folding safety stepladder are illustrated and described in a 12-page booklet.—The Dayton Safety Ladder Company, Miamisburg, Ohio.

Worm Gearing—Catalog 400 devotes 24 pages to a discussion on worm gearing and the use and application of IXL Moderntype worms and worm gears in industrial equipment.—Foote Bros. Gear & Machine Company, 236 North Curtis St., Chicago, Ill.

Variable Speed Transmission — A folder describes and illustrates the use of the splice block for facilitating changing the *V*-belt in the Reeves transmission.—Reeves Pulley Company, Columbus, Ind.

Unit Heater — Catalog 26, section 2-A, devotes 20 pages to engineers' data on the selection and installation of York welded-coil unit heaters.—York Heating & Ventilating Corporation, 1502 Locust St., Philadelphia, Pa.

Speed Reducer—Book 715 discusses the rating, describes the construction and gives other engineering details on the three types of Link-Belt speed reducers with Sykes continuous-type herringbone teeth:—Link Belt Company, 300 West Pershing Road, Chicago, Ill.

Motors—Some interesting installations of Reliance reversing motors are illustrated in Bulletin 1064.—Reliance Electric & Engineering Company, 1053 Ivanhoe Road, Cleveland, Ohio.

Worm Reducers—Application of various types of Cleveland worm reduction gears to small loads, direct-connected loads, overhung gear-shaft loads, vertical drives, and units for high reductions is speed is discussed in Bulletin 106.—The Cleveland Worm & Gear Company, 3268 East 80th St., Cleveland, Ohio.

Monorail Installation—A 20-page supplement for insertion in Monorail Catalog 8 contains 18 dimensioned blueprint pages showing standard methods of steel and wood framing for monorail switches and curves. Catalog 8 devotes 106 pages to descriptions of monorail equipment with illustrations and blueprint diagrams of installations which have been made in various industrial plants throughout the country. — The Louden Machinery Company, Fairfield, Iowa.

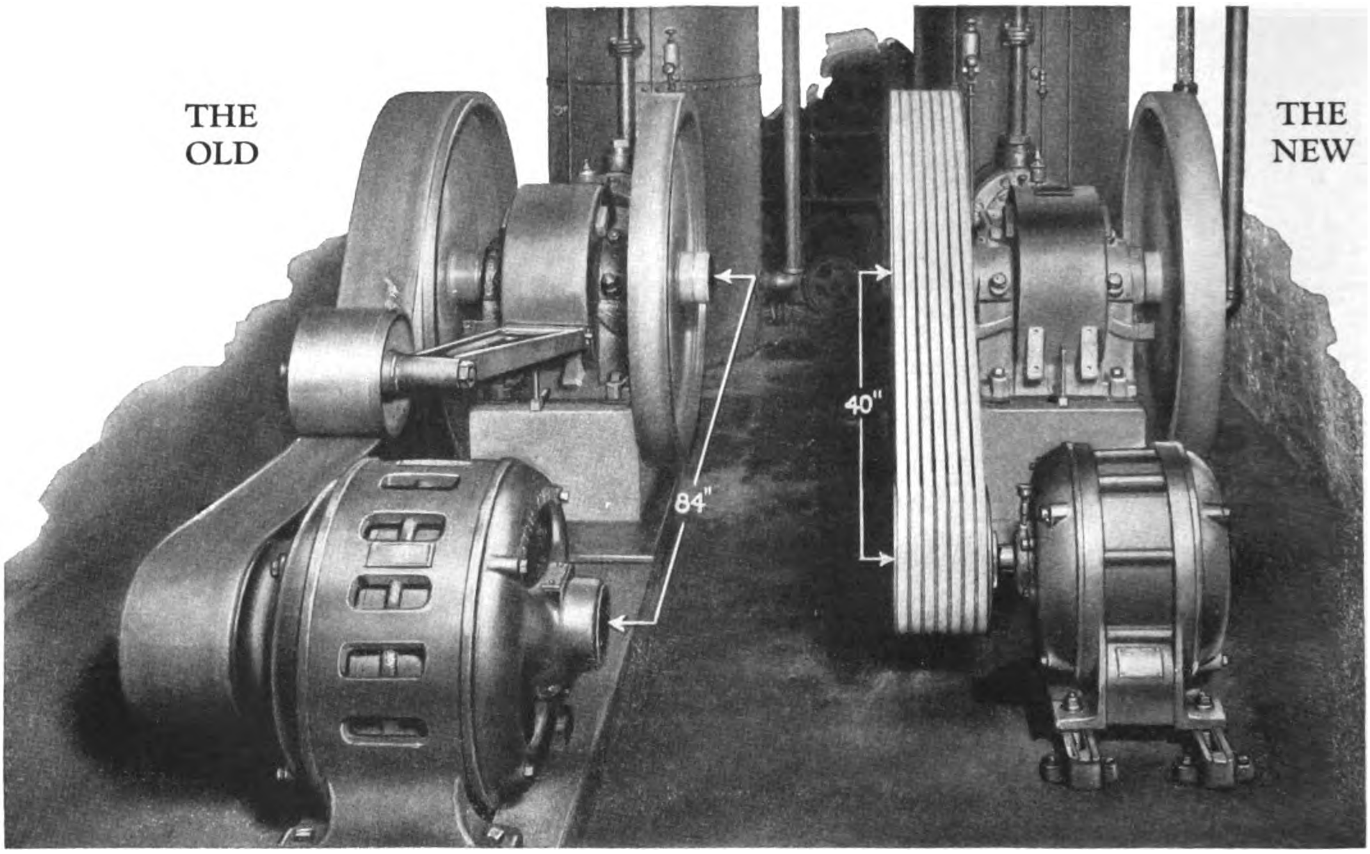
DECEMBER, 1927

INDUSTRIAL ENGINEERING

with which is consolidated

INDUSTRY ILLUSTRATED

Electrical, Mechanical and Plant Service in Industry



Less Power — Less Space — Less Maintenance

Duplicate Compressors, operating at same capacity and pressure.

THE NEW UNIT EMPLOYING TEXROPE ELIMINATES THE IDLER.

The 40" pulley centers on the new unit is less than one-half of this dimension on the flat belt driven unit.

The short belt centers made possible by Texrope Drive and the compactness of the Allis-Chalmers motor with Timkin Bearings result in a big saving in floor space.

The Texrope requires no lubrication; dust does not affect it. The motor is made largely of steel — indestructible rotor — extra sealed insulation — grease packed bearings which require attention only a few times yearly. These features reduce maintenance to a negligible item.

ALLIS-CHALMERS MANUFACTURING CO.
MILWAUKEE
District Offices in Principal Cities

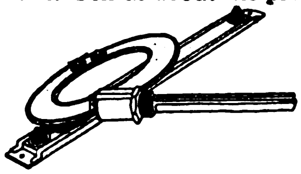
ALLIS-CHALMERS MOTORS and TEXROPE DRIVE

A Combination Unequalled!

Keep any part of *your* plant warm

Air compressor rooms	First Aid stations	Power houses	Sub-stations
Blower rooms	Garages	Pump houses	Valve houses
Crane cabs Elevators	Isolated shops and offices	Sand blast rooms	Warehouses
Drying rooms	Laboratories Lavatories	Scale rooms	Wash rooms
Electric locomotives	Milk storage rooms	Service garages	Watchman houses
Equipment repair shops	Oil and fuel storage rooms	Storage rooms	Welfare buildings

INSTALL these CHROMALOX ELECTRIC HEATERS and end complaints about "It's too cold to work out there"—end costly production delays because places are not properly heated. These fully assembled heaters are quickly mounted on the wall and connected to power lines. Each heater is equipped with a 3-heat switch for regulating temperature to suit weather conditions. 45 Sizes and Ratings. Three types—Horizontal, Vertical and Portable—1000, 1500, 2000, 3000 watts—110, 220, 250 volts. Tell us about the places you want heated—use the coupon!



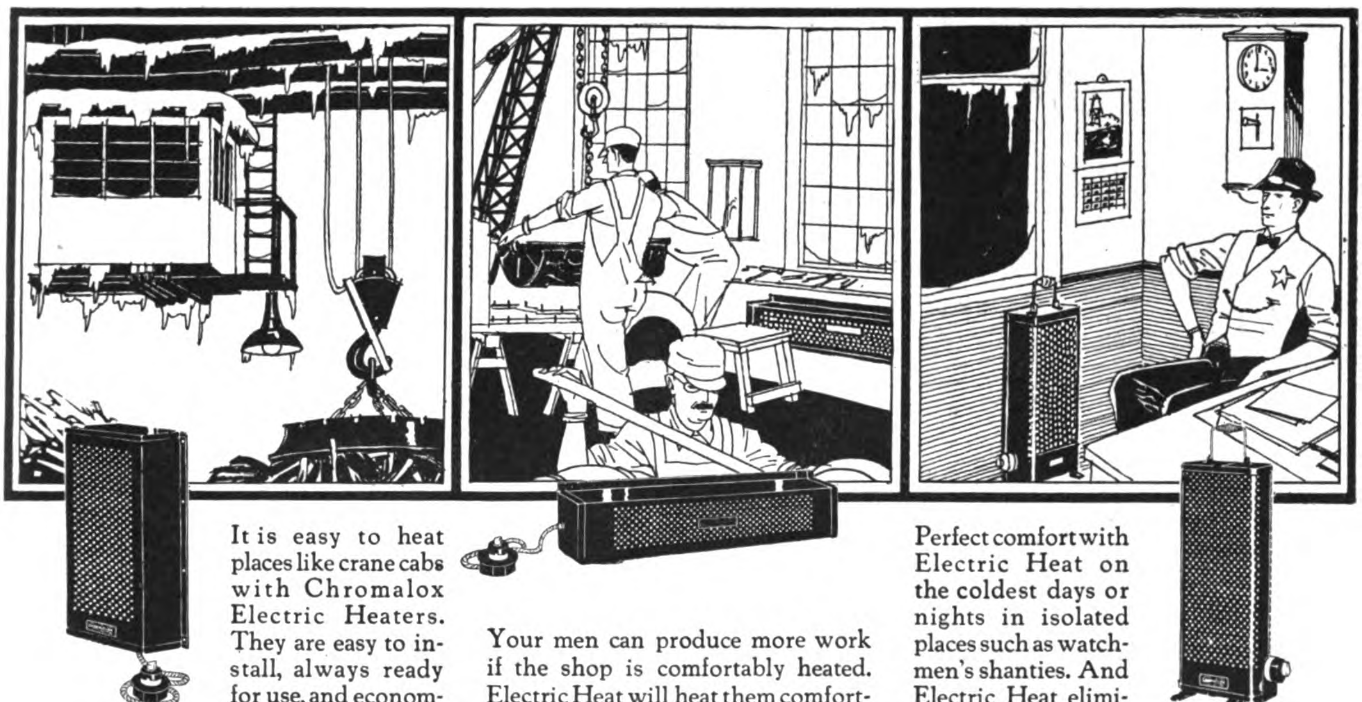
FOR HEATING FLUIDS AND SOLIDS

Certain of the 80 sizes of Strip Heaters, 8" to 72" long .... 11 diameters of Ring Units, 2½" to 11".... or 30 sizes of Immersion Units—all quickly shipped from stock—are sure to fit your applications. Write for Bulletin C-106. What is your job for Electric Heat?

CHROMALOX HEATING UNITS

MANUFACTURED EXCLUSIVELY BY

EDWIN L. WIEGAND CO., 422 FIRST AVENUE, PITTSBURGH, PA.



It is easy to heat places like crane cabs with Chromalox Electric Heaters. They are easy to install, always ready for use, and economical to operate.

Your men can produce more work if the shop is comfortably heated. Electric Heat will heat them comfortably. It is dependable, clean and safe.

Perfect comfort with Electric Heat on the coldest days or nights in isolated places such as watchmen's shanties. And Electric Heat eliminates fire hazards.

Mail with Your Letterhead

PLEASE send Bulletin C-108 about Chromalox Electric Heaters and tell us which type and size will properly heat a space_______ft. long _______ft. wide_______ft. high, having_______[number of] windows _______[number of] doors.

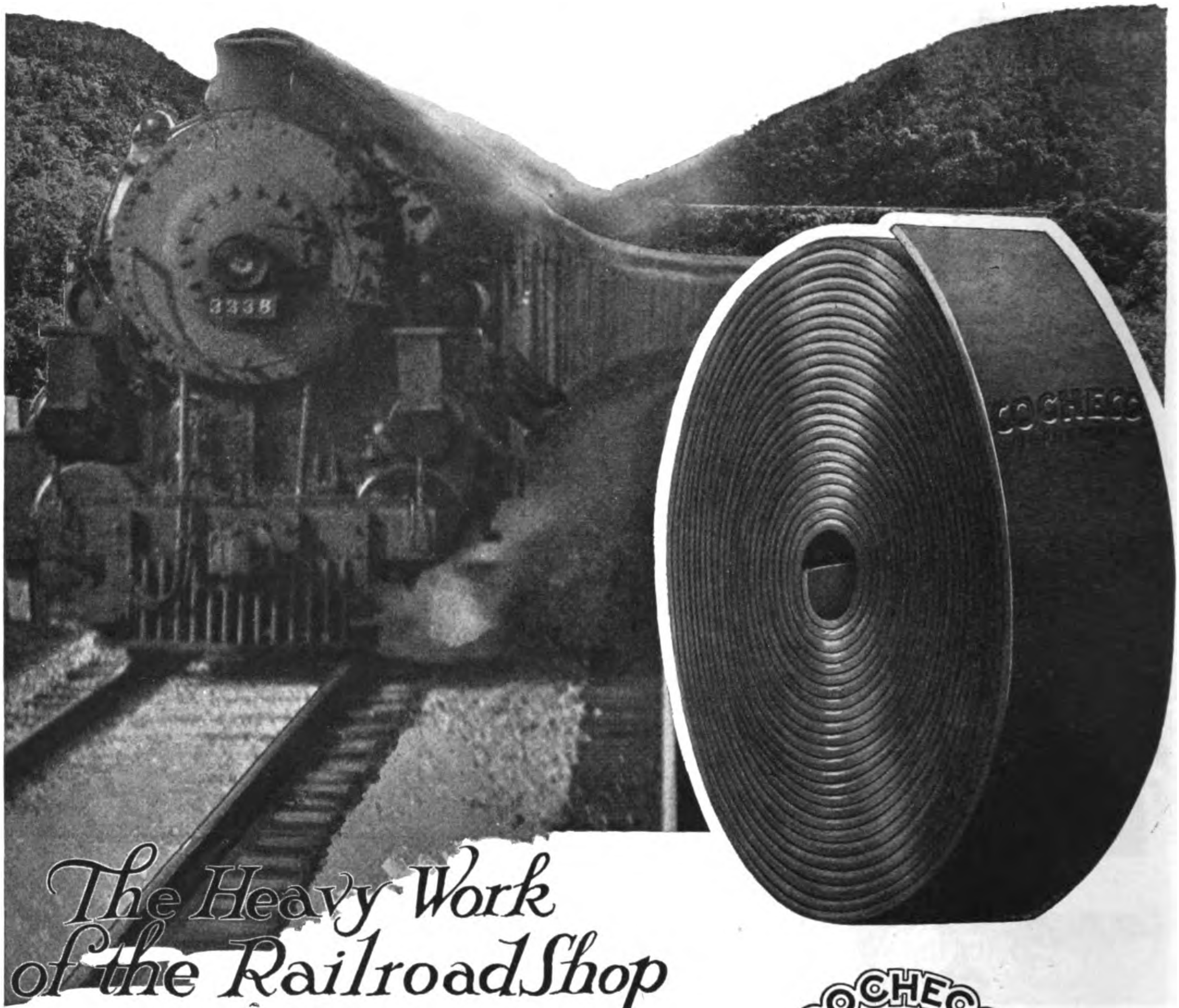
*Signed*____________________ *Position*____________________

I.E. 12-27

CHROMALOX

The Railway Utility Company of Chicago is sole distributor of Chromalox Strip Heaters for use in heating railroad and street cars in the United States and Canada. Sole Canadian Licensees, The Canadian Chromalox Co., Ltd., 321 Queen Street, East, Toronto, Ontario, Canada

"The Power Behind the Product"



The Heavy Work of the Railroad Shop

COCHECO BELTING

The night and day service, the constant, organized, standardized push, requires the strongest driving power—and behind the work, the machines, the rush—you'll find **Cocheco Belts.**

No belt supersedes the leather belt for long, hard service—no belt is better made, from hide to pulley, than the **Cocheco Belt.**

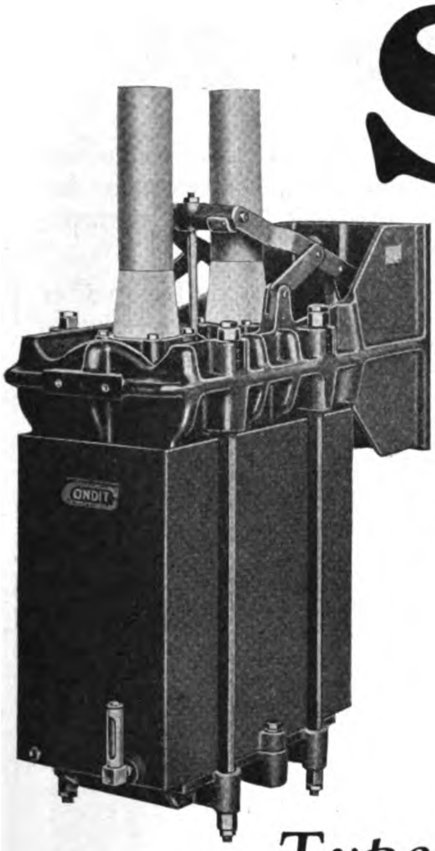
The railroads are keen buyers—no guesswork, no **maybe,** just efficiency and service. Railroad shops in the Northern States, the Middle States, the far West and in the South, specify—**Cocheco Belts.**

Write for the Cocheco Booklet—a Book on Belts.

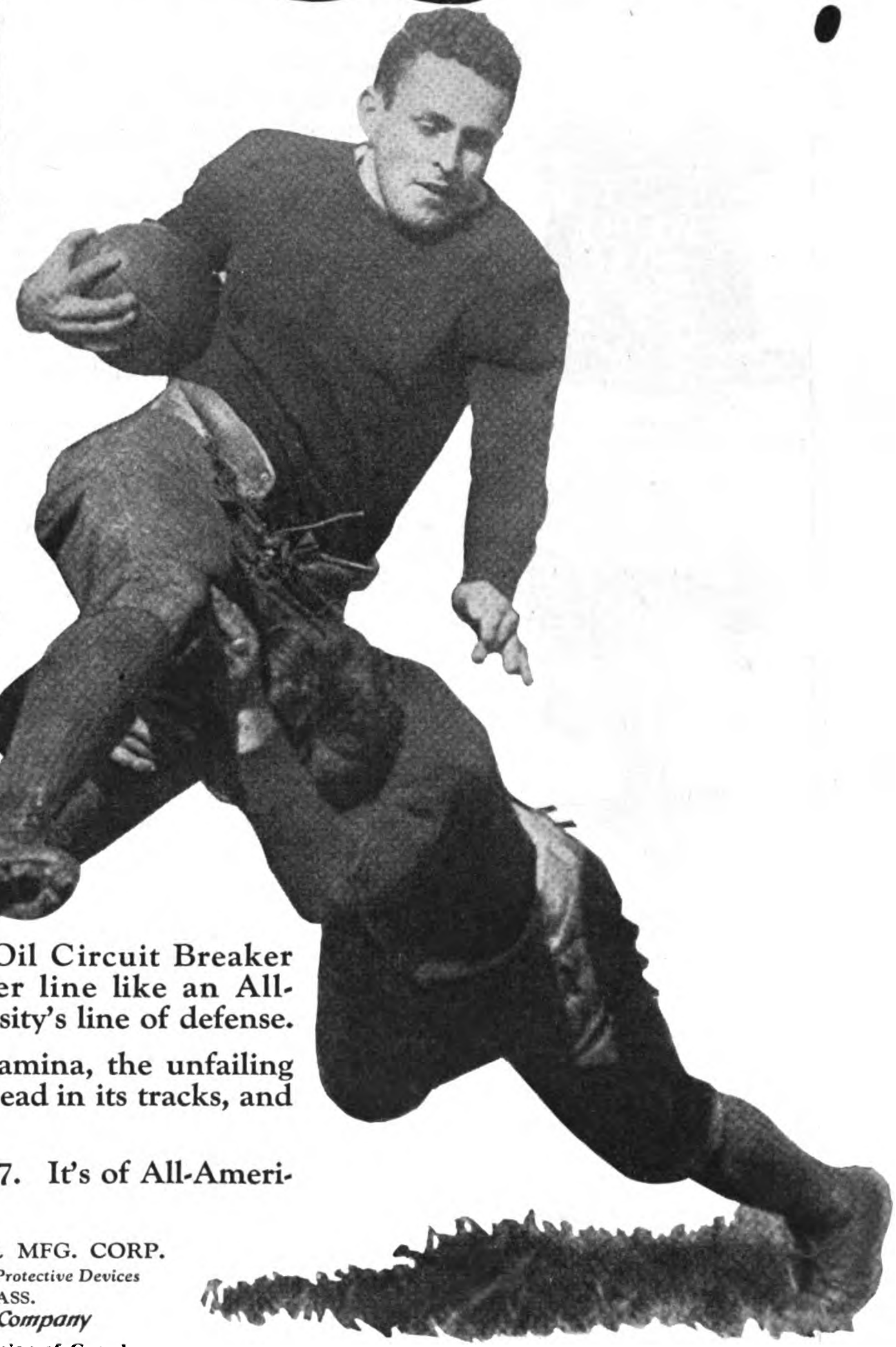
I. B. Williams & Sons, Dover, New Hampshire, U. S. A.

CHICAGO GREENVILLE NEW YORK DETROIT DAYTON BOSTON

Stopped!



Type
D-17



The Condit Type D-17 Oil Circuit Breaker protects your high power line like an All-American giant on the varsity's line of defense.

It has the capacity, the stamina, the unfailing ability to stop the "short" dead in its tracks, and do it again and again.

You can count on the D-17. It's of All-American calibre.

CONDIT ELECTRICAL MFG. CORP.
Manufacturers of Electrical Protective Devices
BOSTON, MASS.
Northern Electric Company
LIMITED
Distributor for the Dominion of Canada

Photo, Keystone View Co.

***SPECIFICATIONS:** 1, 2, 3, and 4 pole manually and electrically operated; up to 1,600 amperes, 7,500 volts; 1,200 amperes, 15,000 volts; 600 amperes, 25,000 volts. Interrupting capacity, 6,000 amperes at 15,000 volts.*

CONDIT

1898

"Still Alive After 25"

"STILL Alive after 25" is a fact of real importance to the men who purchase third rail insulators. Important because service life is the only true standard by which insulator performance can be judged.

Disregard this standard and grief a-plenty follows. Tie-up after tie-up is the order—one insulator failure after another—always "time out" for the repair electrician—he is likely to be the only man who is "worked to death".

"Still alive after 25 years service" . . . that's O-B Third Rail Insulators. A fine tribute to the judgment of the industrial men who selected O-B Insulators for the important work of trouble-free haulage. A tribute to the fact that making third rail porcelain is a job for specialists.

The Ohio Brass Company are specialists in the manufacture of Third Rail Insulators.

The design, porcelain mixture, glaze and firing, in O-B Insulators, are all worked out exactly to fit your demand for heavy, service and long life.

Type D-1
Page 736 of the O-B No 20 Catalog

Ohio Brass Company
100 Surrey Road, Mansfield, Ohio
755M

Type A-1
Page 732 of the O-B No. 20 Catalog

Specialists in —

THE manufacture of materials and devices required in transmitting, distributing and collecting electric current.

Trolley Materials and Fittings
Ears, splicers, hangers, clamps, frogs and section insulators; porcelain, wood and composition strain insulators; bracket arms: line section and quick-break switches.

Rail Bonds
Electric arc and gas weld; pin driven and compressed terminal; 250 and 600-volt resistance type electric welders for bonding and miscellaneous work.

Porcelain Insulators
For any voltage; strain, pin type and suspension; wall and roof bushings; bus and switch insulators; contact rail insulators; high tension line hardware.

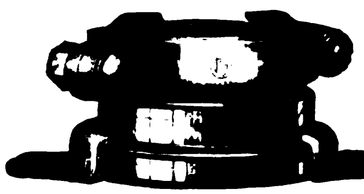
Electric Locomotive Equipment
Trolley wheels and shoes; rigid and swivel harps; headlights, mine and electric railway types.

Brass Valves
Globe, angle, gate and check, including the famous Flexitite gate valve; sizes 1-8-inch to 3-inch high quality standard valves; pressures up to 150 lbs.

Write for catalog No. 20 giving full details of all O-B products. O-B salesmen are available in all principal cities.

Type A-2
Page 733 of the O-B No. 20 Catalog

Type N
Page 746 of the O-B No. 20 Catalog



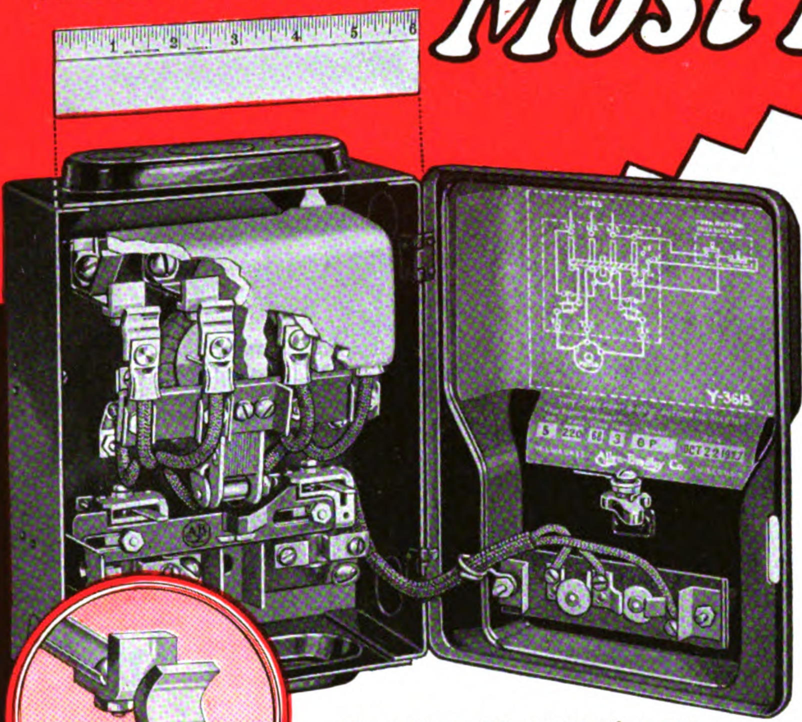
Type B-2
Page 735 of the O-B No. 20 Catalog

Ohio Brass Co.

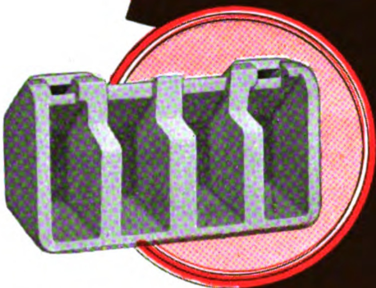
PORCELAIN INSULATORS
LINE MATERIALS
RAIL BONDS
CAR EQUIPMENT
MINING MATERIALS
VALVES

SALES OFFICES: NEW YORK CHICAGO PHILADELPHIA PITTSBURGH CLEVELAND SAN FRANCISCO LOS ANGELES

The Smallest 5 H.P. Starter and the Most Husky!

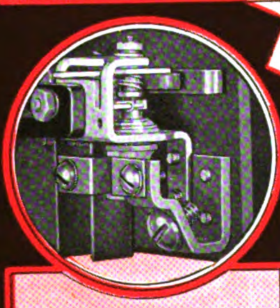


The small Form B Starter is easily mounted on the machine near the motor—it requires little more space than a push button.



Arc barriers are rugged and durable—easily removed to get at contacts.

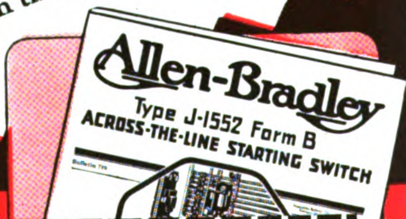
Heavy, simple contactors assure long duty without maintenance costs.



Simple, reliable relay eliminates fuses and furnishes maximum protection.

Features of the J-1552 Form B Starter:

1. Rugged one-piece molded arc barriers.
2. Simple, heavy contactors.
3. Allen-Bradley Resisto-therm Relays.
4. Four contactors—resale buyer is ready for single, two or three phase motor.
5. Rating up to 5 Horsepower, 220; 7½ Horsepower, 440-550 Volts.
6. Three types of cabinet: B-1 with push buttons; B-2 automatic; B-3 automatic or manual.
7. Smallest starter of these ratings on the market.



Mail This Coupon

For bulletin describing the Type J-1552, Form B, Across the Line Starter.

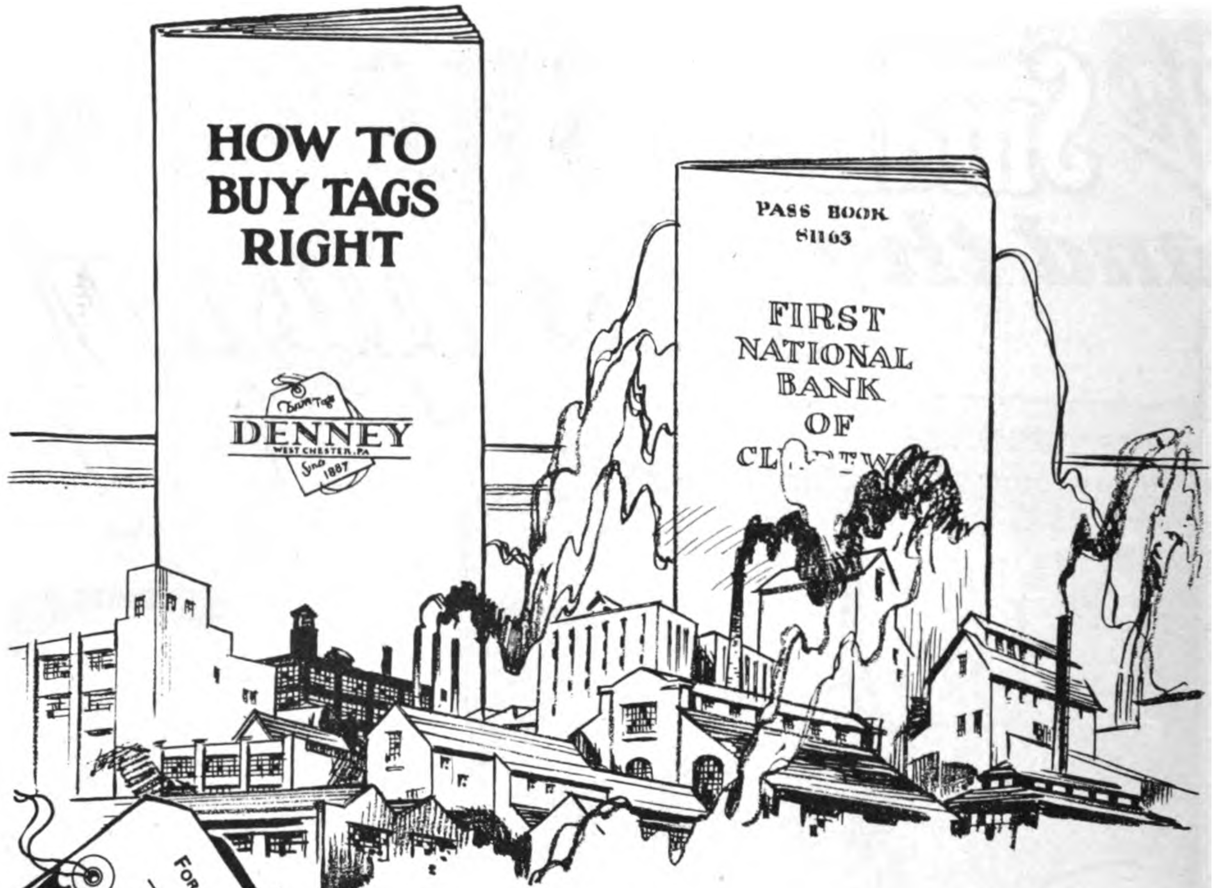
Allen-Bradley Co.
491 Clinton St., Milwaukee, Wis.

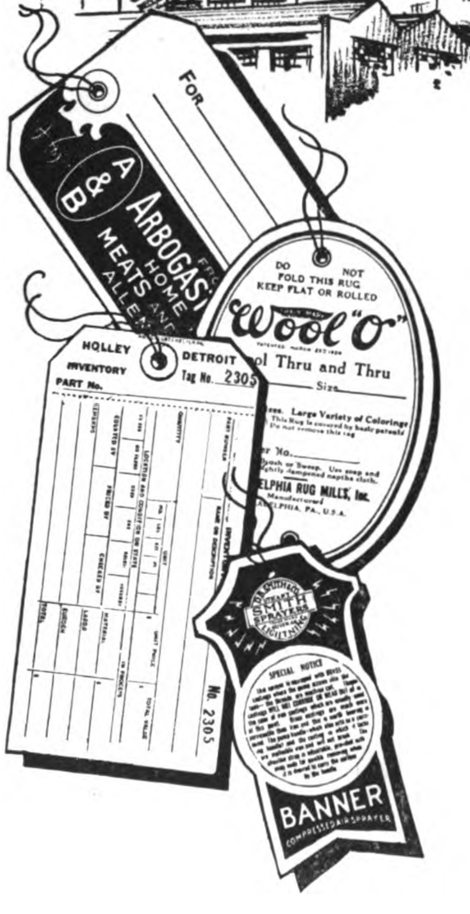
Name ....

Address ....

....

Allen-Bradley Starters





One book will help you put more figures in the other!

The right tag in the proper place does more than save money—it makes money.

Work flows more smoothly and more quickly through the plant when instructions are given by means of well designed process tags.

Shipping tags of the right kind guard against delivery delays—dissatisfaction and cancelled contracts.

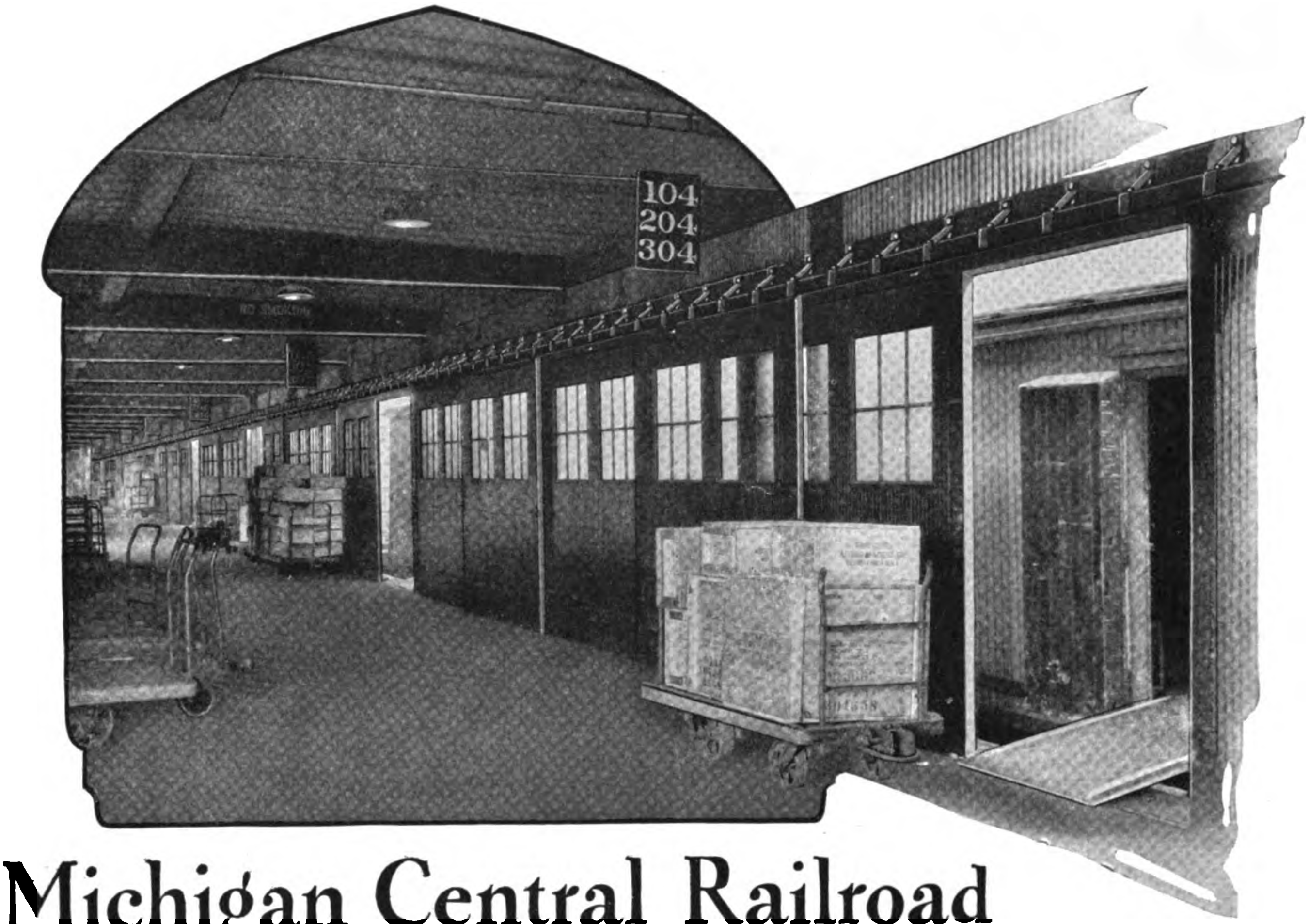
Good tags play a prominent part in industrial efficiency and the booklet "How to Buy Tags Right" shows and explains just what these tags are like.

Write for your copy today.

The DENNEY TAG COMPANY

24-26 W. Barnard Street, West Chester, Pa.

The World's Largest Plant Devoted Exclusively to Making Tags



Michigan Central Railroad
equips over 300 doors with R-W-

"The doors operate easily year after year. Our satisfaction is indicated by our constant re-orders"

J. F. Deimling, Chief Engineer, Michigan Central Railroad, says:

"In January, 1926, we completed a new 1190 ft. section of our freight house, making the total length 2000 ft.—perhaps the longest railroad freight house in the country. On one side of the freight house are the tracks; on the other side is a roadway where teams and trucks are constantly loading and unloading.

"In the original section of this freight house, which is 10 years old, we used Richards-Wilcox door hardware. Being perfectly satisfied with our 10 years' experience, we naturally selected R-W equipment for the newer additions. R-W equipped doors of the sliding type line the railroad track side of the freight house. On the teaming side, we use a vertical rolling door. All door openings are 9x9 ft.

"In June, 1926, we completed a new inbound freight house of the same type, three sets of tracks away. This building is 590 ft. long, with R-W equipped sliding doors throughout.

"Altogether, we have in these two freight houses over 300 doors equipped with R-W hardware, slides, and trolleys. We also have several FyReWall doors of Richards-Wilcox manufacture, as well as a folding door 17 ft. wide by 12 ft. high.

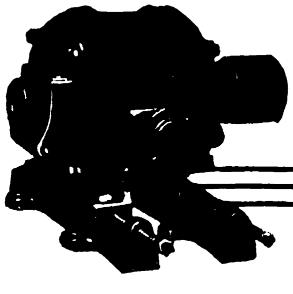
"At present we are constructing the Michigan Central Fruit Auction Building, which will be equipped throughout with R-W bi-fold and sliding doors and hardware.

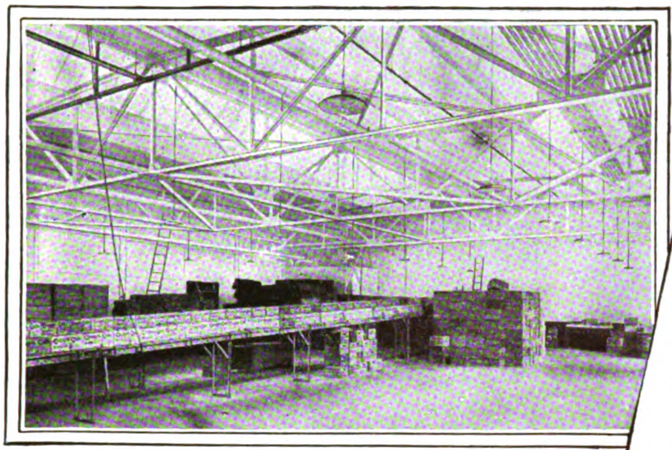
"We have never had a complaint about our Richards-Wilcox equipment. The design is right, and the doors operate easily year after year. Our satisfaction is indicated by our constant re-orders."

R-W Engineers will gladly make an analysis of your plant requirements in the matter of doorways and conveying problems, without placing you under any obligation. Just write our nearest branch office.

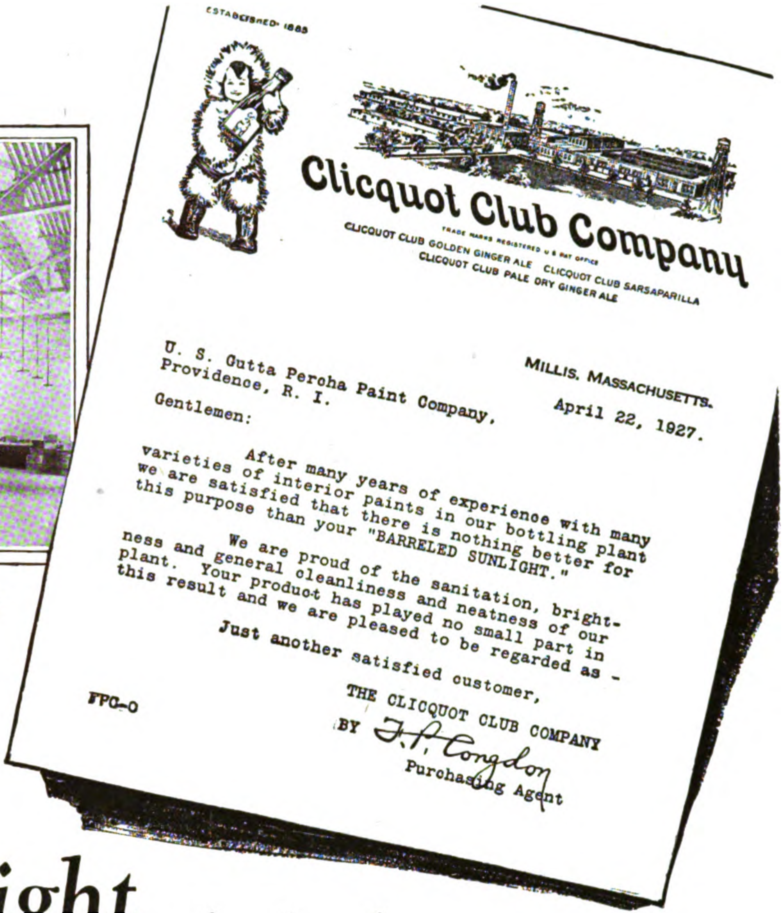
Richards-Wilcox Mfg. Co.

A Hanger for any Door that Slides





A glimpse into the model plant of the Clicquot Club Company at Millis, Mass.—painted with Barreled Sunlight for lasting cleanliness and better light



ESTABLISHED 1885

Clicquot Club Company

TRADE MARKS REGISTERED U.S. PAT. OFFICE

CLICQUOT CLUB GOLDEN GINGER ALE CLICQUOT CLUB SARSAPARILLA
CLICQUOT CLUB PALE DRY GINGER ALE

MILLIS, MASSACHUSETTS.

U. S. Gutta Percha Paint Company,
Providence, R. I.

April 22, 1927.

Gentlemen:

After many years of experience with many varieties of interior paints in our bottling plant we are satisfied that there is nothing better for this purpose than your "BARRELED SUNLIGHT."

We are proud of the sanitation, brightness and general cleanliness and neatness of our plant. Your product has played no small part in this result and we are pleased to be regarded as -

Just another satisfied customer,

THE CLICQUOT CLUB COMPANY
BY F. P. Congdon
Purchasing Agent

FPC-O

Painted with Barreled Sunlight . . .

This famous plant is kept light, cheerful and sanitary

THE testimonial letter reproduced above is just one of the many that tell how Barreled Sunlight increases efficiency by improving working conditions. More light and lasting, sanitary cleanliness.

Experience has shown the Clicquot Club Company that to keep ceilings and walls white, lustrous, immaculate—without frequent repainting—nothing takes the place of Barreled Sunlight.

* * *

A pure white finish that reflects light of just the right quality—free from glare.

A surface so smooth it can't hold dirt embedded, and washes like tile.

Guaranteed to remain white longer than any gloss paint or enamel, domestic or foreign, applied under the same conditions.

Will not flake or scale if properly applied.

Yet with all these advantages, Barreled Sunlight costs no more on the finished job than many paints priced less per gallon! It flows so freely and covers so well that *less paint* is required; and is so easy to apply with brush or spray that there is also a big *saving in labor*.

Sold in 55- and 30-gallon churn-equipped steel drums, and in cans. For priming, use Barreled Sunlight Undercoat. See coupon.

U. S. Gutta Percha Paint Co., 5 Dudley Street, Providence, R. I.—New York, 420 Lexington Ave.; Chicago, 659 Washington Blvd.; San Francisco, 156 Eddy Street. Distributors in all principal cities.

* *

Now we offer Outside Barreled Sunlight, and recommend it with the same assurance as we recommend Interior Barreled Sunlight. Write for information as applied to your own outside painting.

Save the surface and you save all

Barreled
Reg. U. S. Pat. Off.
Sunlight

THE RICE PROCESS WHITE

U. S. GUTTA PERCHA PAINT CO.
5 Dudley Street, Providence, R. I.

Please send me your booklet "More Light" and a panel painted with Barreled Sunlight.

Name..

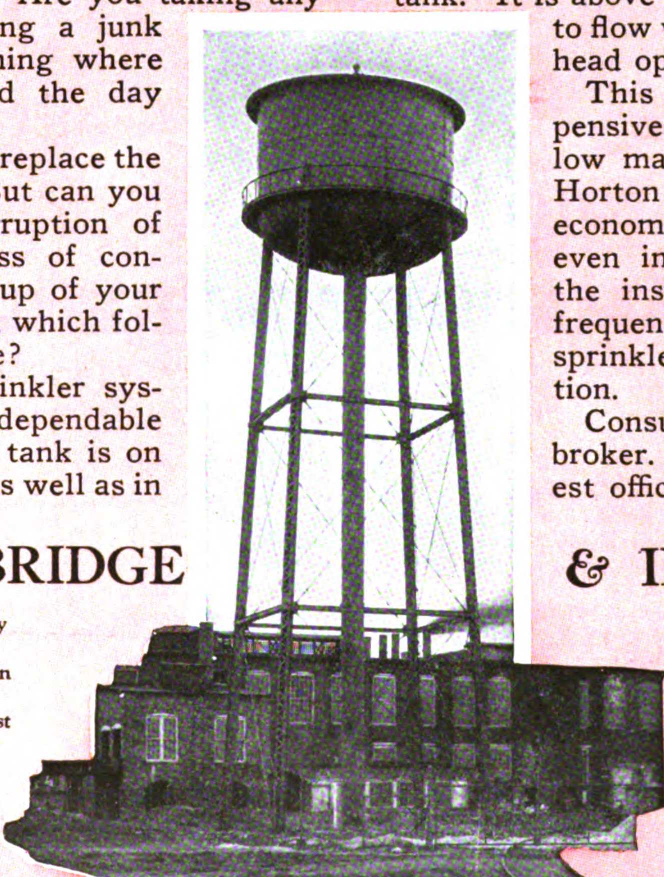
Street..

City..........................*State*............

FIRE lurks in shadows of night. During the hours of darkness and inactivity in your plant a small blaze has more chance to get started than it does during the day. Are you taking any chances of finding a junk heap some morning where your plant stood the day before?

Insurance may replace the property loss. But can you afford the interruption of business, the loss of contracts, breaking up of your organization, etc, which follow a serious fire?

A modern sprinkler system served by a dependable Horton elevated tank is on the job at night as well as in the day. It stands ready to drench a small blaze with water. There is no uncertainty about the water supply when it is stored in a Horton elevated tank. It is above your property ready to flow whenever a sprinkler head opens.



This protection is not expensive. The long life and low maintenance cost of a Horton Tank make it the economical storage unit even in small sizes. And the insurance savings will frequently pay the cost of a sprinkler and tank installation.

Consult your insurance broker. Then ask our nearest office for quotations.

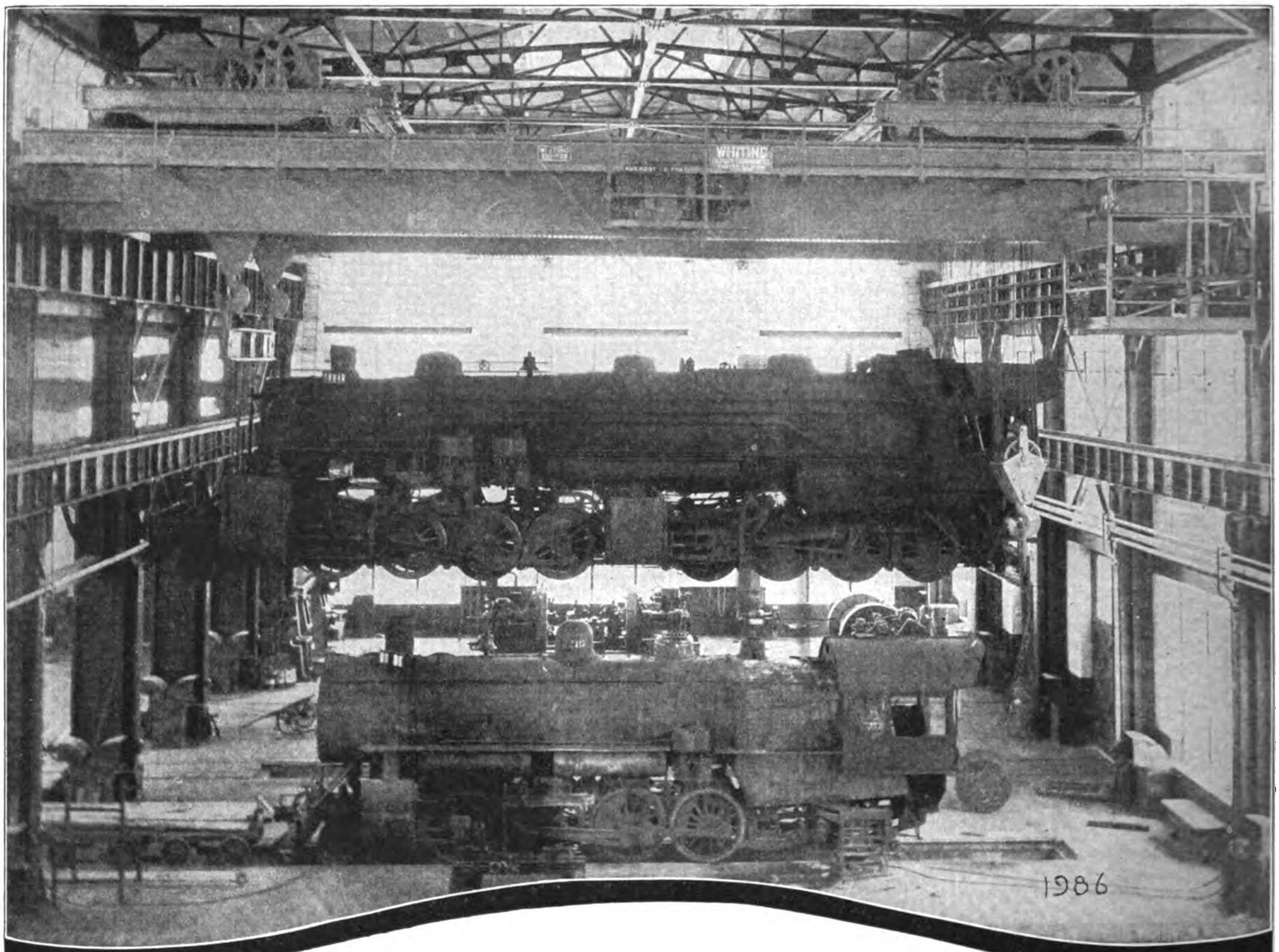
CHICAGO BRIDGE & IRON WORKS

Chicago: 2465 Old Colony Bldg.
New York: 3169 Hudson Terminal Bldg.
Cleveland: 2238 Union Trust Bldg.

Dallas: 1658 Dallas National Bank Bldg.
Atlanta: 1023 Healey Bldg.
San Francisco: 1043 Rialto Bldg.

HORTON TANKS

IM-12-Gray



WHITING CRANES
+
WILLIAMSPORT WIRE ROPE

There's a combination that leaves no room for doubt about quality.

WE HAVE steadfastly maintained that where a manufacturer uses **known** quality—accessories that are accepted by the user as of the highest grade such as Williamsport Wire Rope—you have a right to feel a sense of security in your selection of the entire unit.

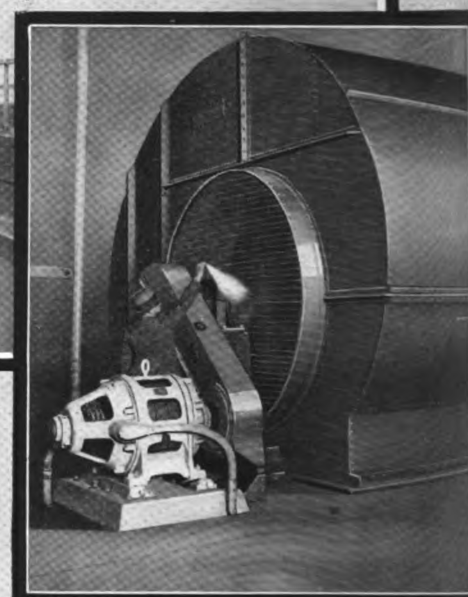
Williamsport Wire Ropes are Good Ropes—as good as ropes can be made. If we could tell you how we make them in this story you'd agree with us. We are proud of our product—that's why we weave our name into them.

When you see the Telfax Tape in the hemp core, it's a factory certification of the grade and is printed there in plain English. If you don't see it, you have a right to feel that you may not be getting your money's worth. You may be—but there's room for reasonable doubt.

Eliminate this doubt by insisting upon Williamsport. Play safe—you'll find Williamsport in nearly all high class equipment. You'll not likely find it on equipment where the maker is "cutting corners" on price, because Williamsport is not a cheap rope. It can't be—it isn't made "cheap."

WILLIAMSPORT WIRE ROPE CO.
Main Office and Works: Williamsport, Pennsylvania
General Sales Offices: 122 So. Michigan Ave., CHICAGO
Use MADESCO TACKLE BLOCKS, They Stand The Gaff

WILLIAMSPORT
CERTIFIED WIRE ROPE



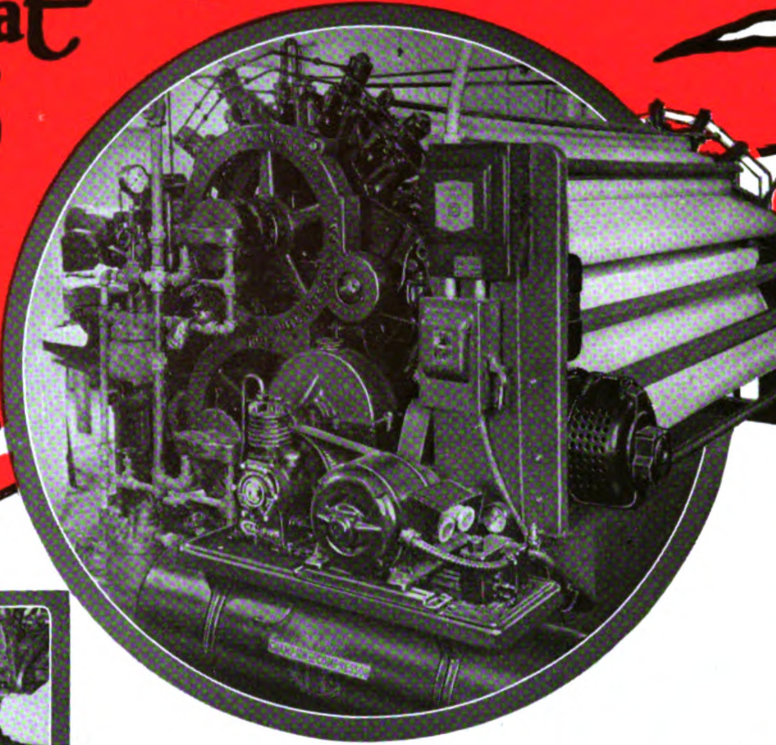
MAINTENANCE EXECUTIVES

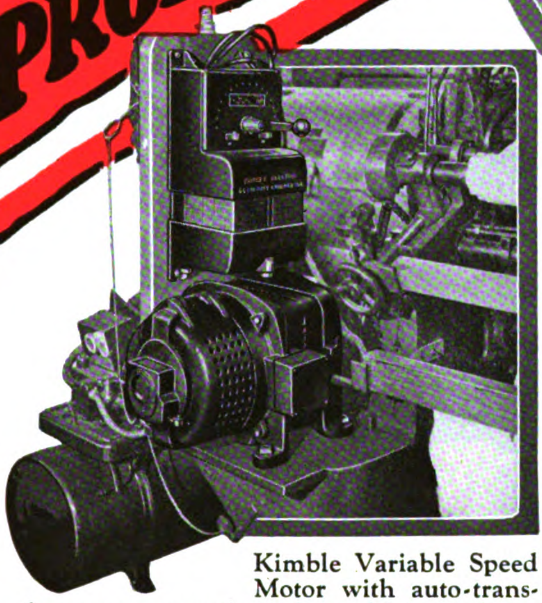
WRITE FOR THIS FOLDER

Here, in concise form, is information as to how to save time and money in soldering, brazing and a wide range of other maintenance operations where heat is a factor. This literature describes the modern blow torch, which uses Prest-O-Lite gas, and avoids the dangers and delays involved in using the older types of torches. Your copy can be obtained by addressing

THE PREST-O-LITE COMPANY, *Inc.*
New York INDIANAPOLIS San Francisco
In Canada, Prest-O-Lite Company of Canada, Ltd., Toronto, Ontario
Unit of Union Carbide and Carbon Corporation

A Variable Speed Motor that Solves SPEED CONTROL PROBLEMS





Kimble Variable Speed Motor with auto-transformer type speed regulator driving a laundry machine. Kimble Motors are reducing costs and increasing production in many leading industries. If you have a speed control problem, submit it to Kimble Engineers for their recommendation.

KIMBLE Variable and Adjustable Speed Motors and Control systems are solving speed control problems for hundreds of manufacturers in many leading industries.

Kimble Motors are made in several different types, each type being particularly suited for certain applications. To select the correct variable speed motor for a given application, experience with variable speed motor drive is essential. Kimble Engineers have acquired this experience over a period of many years.

Kimble recommendations, given at no extra cost, assure satisfactory results from variable speed motors. Submit your variable speed problems and learn what Kimble Variable Speed Motors can do for you.

KIMBLE MOTORS

HAVE SOLVED SPEED CONTROL PROBLEMS SINCE 1905

KIMBLE MOTORS

MAIL THIS COUPON

for literature describing the Kimble Variable and Adjustable Speed A. C. Motors

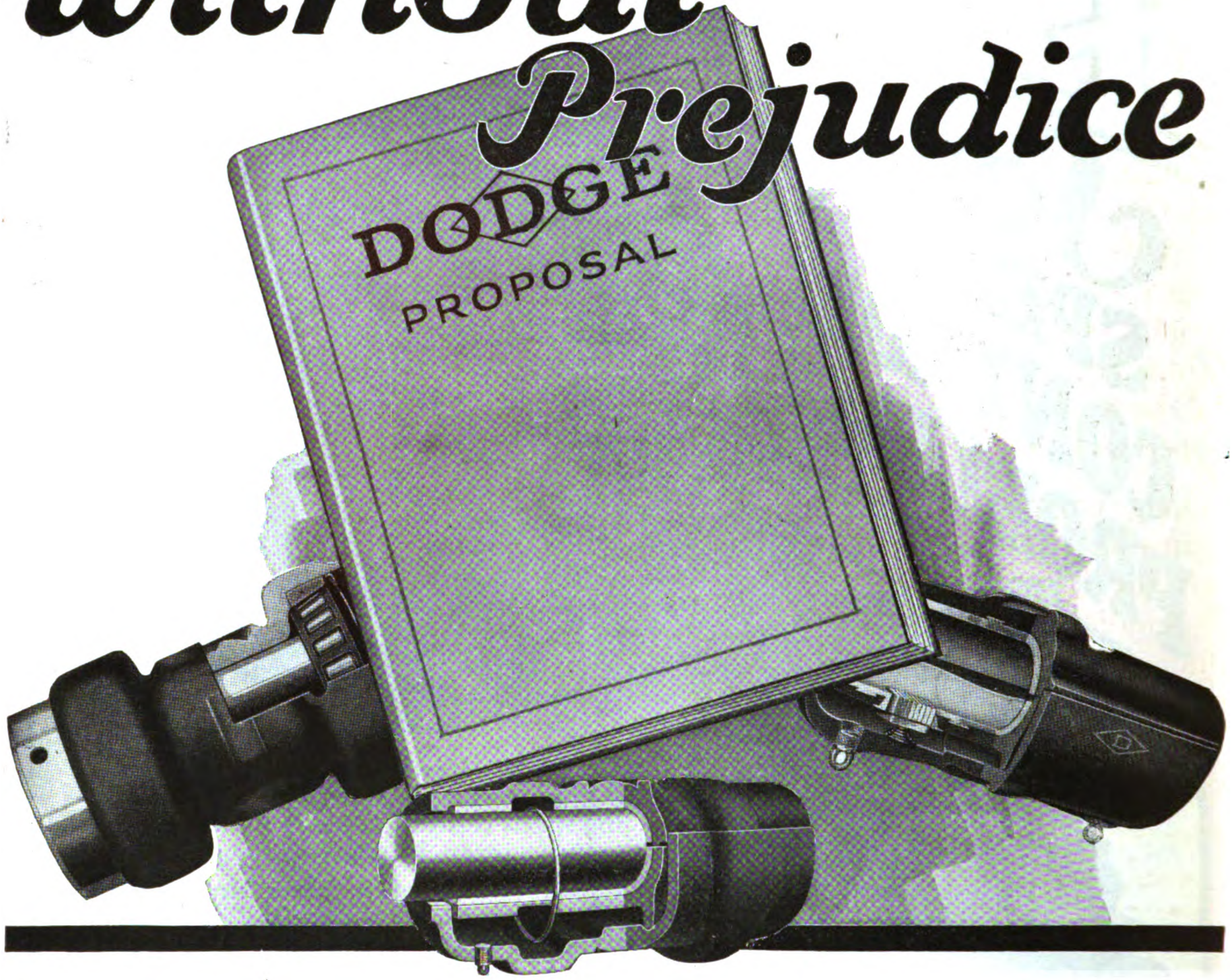
KIMBLE ELECTRIC COMPANY
642 North Western Avenue, Chicago, Illinois

Name ....

Address ....

Position ....

Without Prejudice



Conditions dictate type of appliance to be used for mechanical power transmission. There should be no argument as to whether ring oiling, capillary or low friction bearings should be used because each type serves efficiently and economically under certain conditions.

The Dodge complete line including not only every appliance for the mechanical distribution of power but every type of every appliance for the transmission of power under all conditions of service was evolved over a period of 47 years of close study of power plant requirements.

A Dodge proposal is submitted without prejudice as to type. It will include recommendations based on service conditions and specify that particular layout which will insure continuous, uninterrupted production at low cost and low maintenance.

Fitted to Your Plant Requirements

Engineering authorities all agree that close study of power layout is essential to insure efficient operating conditions and low costs. They also agree that there are conditions in a single plant where individual, group and line shaft drives should all be used in order to insure maximum operating satisfaction.

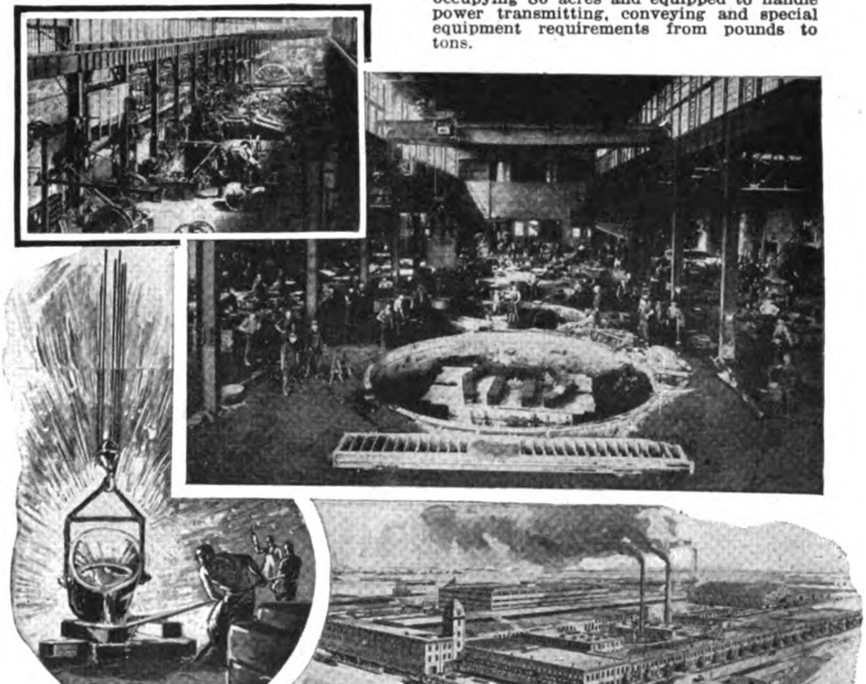
Dodge engineers have studied power layout—they have prescribed for thousands of the largest industries and without prejudice. Dodge can render its greatest service when called upon to survey plant power requirements.

Close study of power problems pay dividends in lower costs, better arrangement, more favorable working conditions and lower upkeep.

You can call in a Dodge engineer at any time without obligation. You can buy Dodge transmitting appliances on the immediate delivery basis from five hundred qualified distributors who carry well assorted stocks based upon their market requirements and who have at their disposal all of the facilities of the Dodge organization.

If the Dodge catalogue is not a part of your plant library, it should be. A request on your business letterhead will bring it.

The Dodge plant at Mishawaka, Indiana occupying 80 acres and equipped to handle power transmitting, conveying and special equipment requirements from pounds to tons.



DRIVE RIGHT
POWER TRANSMISSION ASSOCIATION

DODGE
MISHAWAKA

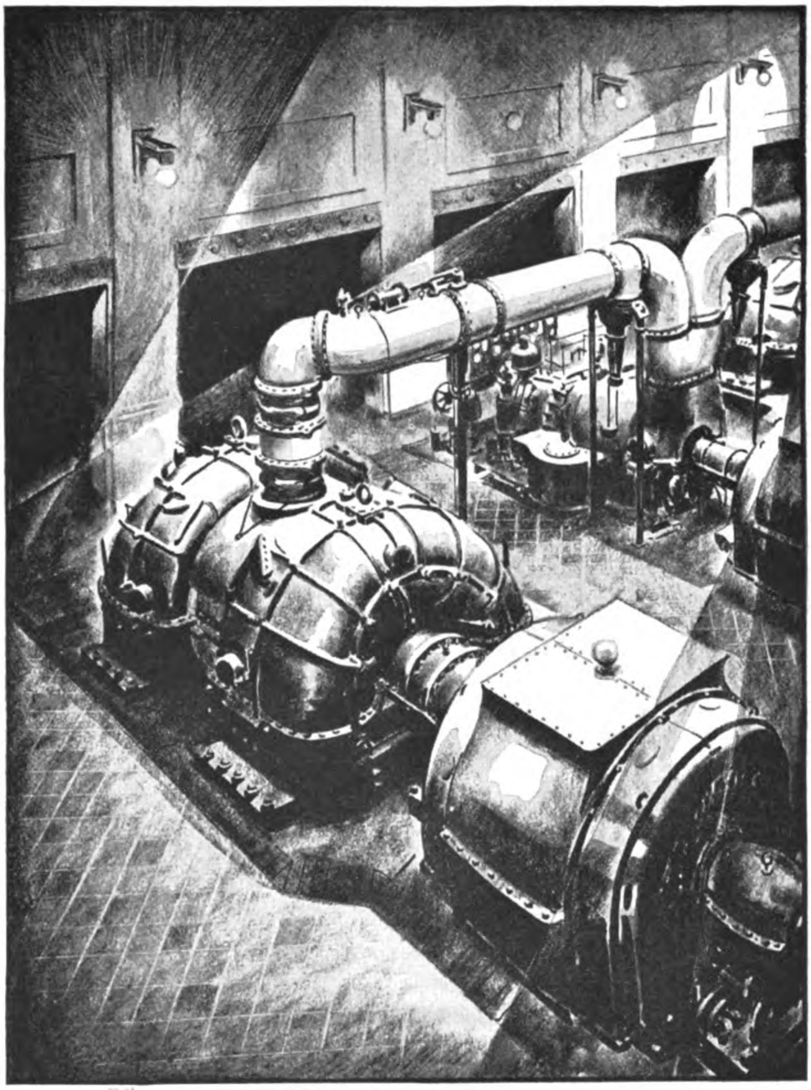
CHICAGO
POWER SHOW
FEB. 14-18

DODGE MANUFACTURING CORPORATION

MISHAWAKA, INDIANA

Power Transmission—Material Handling—Special Machinery

Wheels that turn while the world sleeps



Black night envelops the world—a glow of light reflected from the earth upon low hung clouds tells the story of a city at play. Three, four, five hours later—dimmed reflections above—the city sleeps, its bright lights out.

* * *

On the outskirts of the city a huge building topped by a towering stack—within the high brick walls a spotless floor—lights overhead—perfect vision everywhere—scarcely a human figure to be seen—only huge black shapes that whir and hum the whole night through the never-ending song of power.

* * *

Thus is power generated in hundreds of cities and towns, to be dispatched over radiating copper highways—to industry, to homes, to cities at play and cities asleep. Constantly growing, this network of copper cables and copper wires is helping to guarantee to the future millions of America ample power and ample light.

ROME WIRE COMPANY
Division of General Cable Corporation
Rome, N. Y.

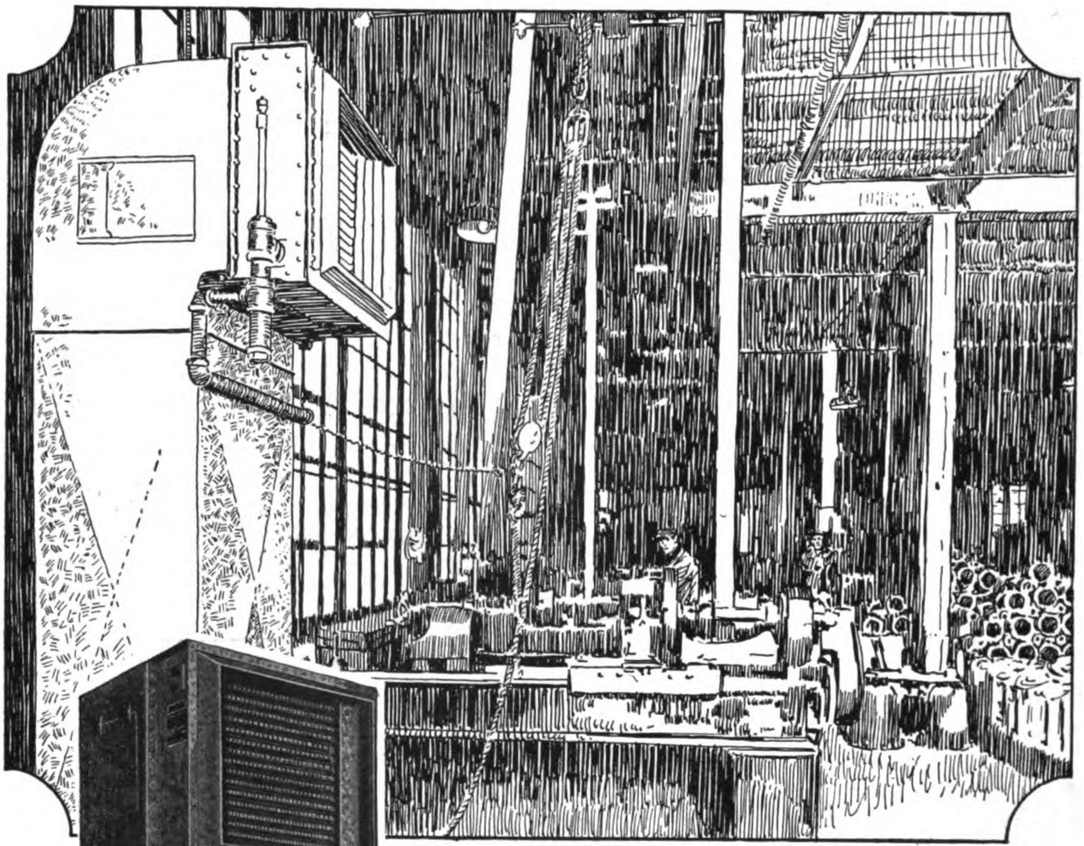
BARE & TINNED WIRES · · · POWER CABLES · MAGNET, WEATHERPROOF & RUBBER COVERED WIRES · FLEXIBLE WIRES, CABLES & CORDS · · SIGNAL & TELEPHONE WIRES · · · LEAD & STEEL TAPED CABLES · SUPER SERVICE CORDS & CABLES · ROMEX · · · SPECIAL WIRES to SPECIFICATIONS

ROME WIRE

2748

FROM WIRE BAR TO FINISHED COPPER WIRE


BUSS FUSES
TRADE BussFuses ELECTRICITY'S SAFETY VALVE MARK REG. U.S. PAT. OFF.
APPROVED IN ALL TYPES AND SIZES
An interior view of the Niles Tool Works, Hamilton Ohio, makers of the famous Niles boring mills, large machine tools and cranes.
They are reputed to be the world's largest manufacturers of large machine tools and are Buss Renewable Fuse users 100%.
It was because they realized the value of dependable electrical protection that they equipped their huge plants with Buss Renewable Fuses.
You, too, can have this same protection. Send for a sample of a Buss renewable fuse. An examination will prove its superiority.
BUSSMANN MFG. CO. St. Louis, Mo.
4 parts and the Link
That's All!



This factory SAVED $2695.00 in cost—Saves more than

$265.00 each year in fixed charges--lower maintenance and lower operating costs!

The factory pictured above is a one-story brick and steel building 185 feet long and 60 feet wide. Flat roof—15 feet above the floor.

Direct radiation figured 2,400 square feet—at $1.50 per foot—$3,600.00. Breezo-Fin Unit Heaters to handle the requirements cost $905.00. This gives a saving of $2,695.00 in first cost while there is a saving in fixed charges of more than $265.00 per year.

Breezo-Fin heaters cost less to install than direct radiation and less to operate.

When you have occasion to buy heating equipment, let us quote on modern efficient heaters—You'll save money.

Branch Engineering Offices in All Principal Cities.

Buffalo Forge Company

CHICAGO POWER SHOW FEB. 14-18

441 Broadway, Buffalo, N. Y.

"HEAT WITH UNIT HEATERS"

IN CANADA—CANADIAN BLOWER & FORGE CO., LTD., KITCHENER, ONT.

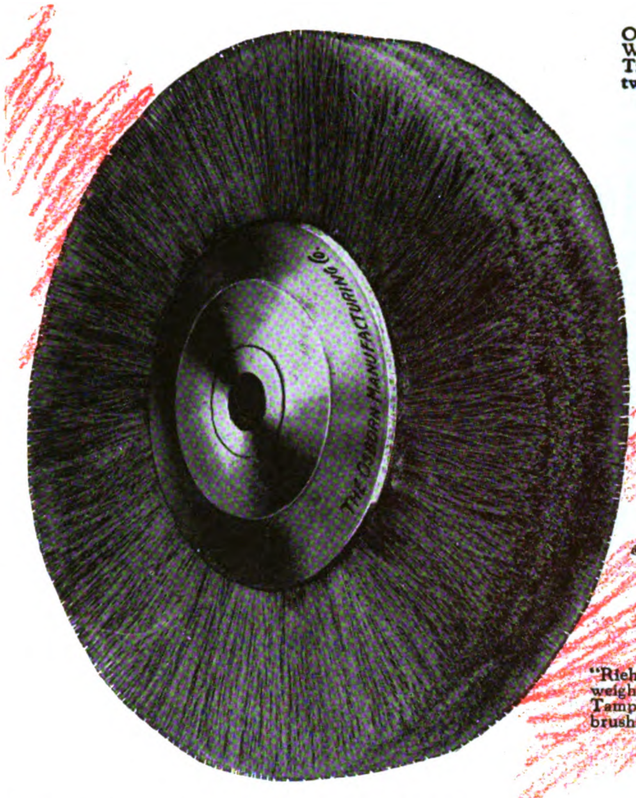
"Buffalo"

BREEZO-FIN UNIT HEATERS


Report of Tests Showing
Saving of
FAFNIR BALL BEARINGS
vs
FRICTION BEARINGS
THE FAFNIR BEARING CO.
NEW BRITAIN, CONN.

Osborn "Riehl-Triumph" Tampico Wheels are made up of one or more Triumph Sections firmly held by the two-piece adjustable and self-locking aluminum hubs. Diameters 6" to 16".

OSBORN



"Riehl" Aluminum Hub. Light in weight and designed to compress Tampico Sections into a compact brushing face. Face widths 1½" to 3". Arbor holes any size desired.

Better Wearing Tampico Wheels

The complete line of Osborn Tampico Wheels makes it easy to choose exactly the right type of brush for any kind of work. Three distinct types are available in a wide range of diameters and face widths.

"Riehl-Triumph" Tampico Wheels are composed of one or more Triumph Sections [according to width face desired] mounted on two-piece, adjustable and self-locking aluminum hubs, which can be refilled with new sections when the original brush parts are worn out.

"Solid-Triumph" Wheels are built up of more than the average weight of selected fibre, held firmly in a center stamping.

"Knot-Type" Wheels are staple-set in solid, hardwood blocks and are guaranteed against tufts pulling out.

The economy of these tools is wholly a matter of durability and uniform wear, which Osborn Tampico Wheels provide in fullest measure.

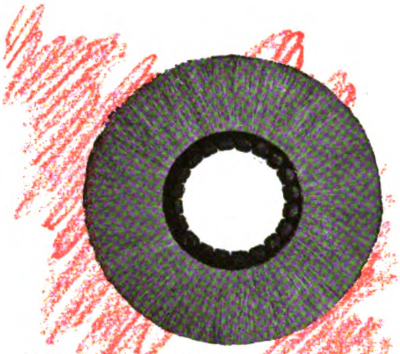
THE OSBORN MANUFACTURING COMPANY
INCORPORATED

5401 Hamilton Ave. **Cleveland, Ohio**

Branch Offices

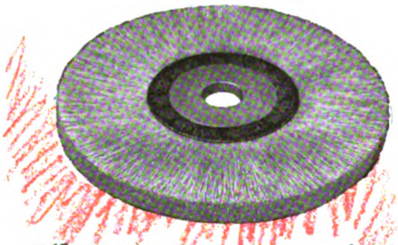
New York Detroit Chicago San Francisco Los Angeles

Osborn Brushes

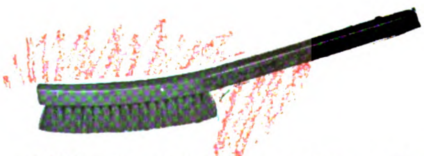


1518—"Triumph" White Tampico Section. Designed for use with "Riehl" hubs. Furnished in fine or coarse grades of Tampico Fibre and in diameters from 6" to 16".

458—"Knot-Type" Tampico Wheels. Made on thoroughly seasoned, hardwood blocks, with each tuft separately stapled into a hole. Diameters 6" to 12".



4068—Monarch Tampico Sections are designed to meet the need for individual sectional units which can be used without a hub, and built up to any width desired. Diameters 8" to 12".



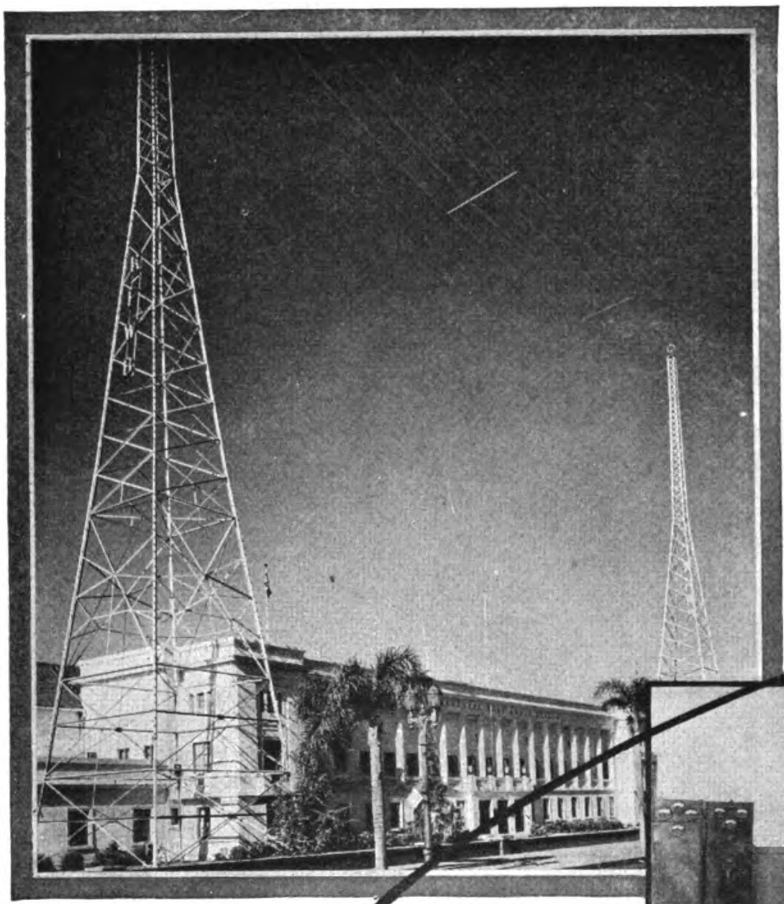
263A—Plater's Brush. Tampico Fibre, staple-set in solid block with curved handle.

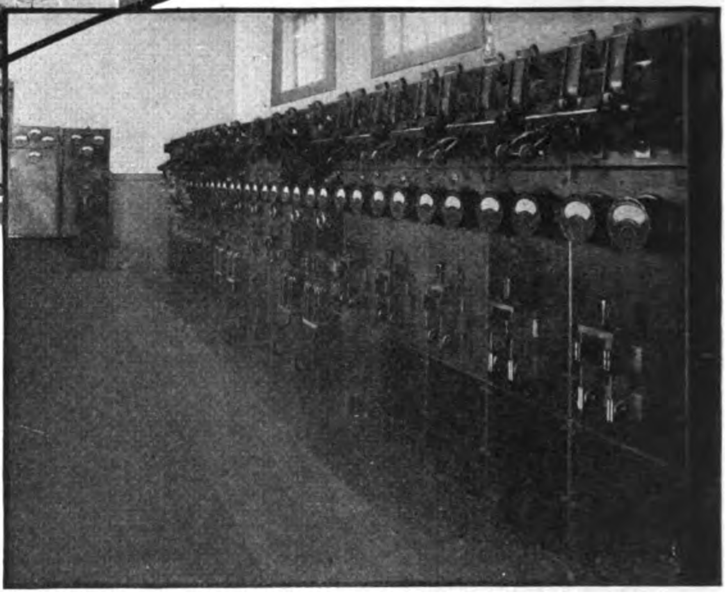
278—Plater's Brush. Tampico Fibre, staple-set in solid block with shoe handle.

A BETTER WEARING BRUSH FOR EVERY USE

ROLLER SMITH

Circuit Breakers
and
Instruments
at the





Warner Brothers West Coast Studios Hollywood, Cal.

The magnificent West Coast Studios of Warner Brothers, Hollywood, California, house a 20 panel switchboard which was designed, constructed and installed under the direction of Mr. F. N. Murphy, Chief Electrician for Warner Brothers.

The total output is over 12,000 amperes, but the overloads are frequent and tremendous. The installation has been operating for four years **with 100% satisfaction.**

There are fourteen ROLLER-SMITH circuit breakers ranging in capacity from 1000 amperes down.

There are thirty-seven ROLLER-SMITH Types SA and SD (7½ inch round) instruments.

"Over thirty years' experience is back of ROLLER-SMITH"

ROLLER-SMITH COMPANY

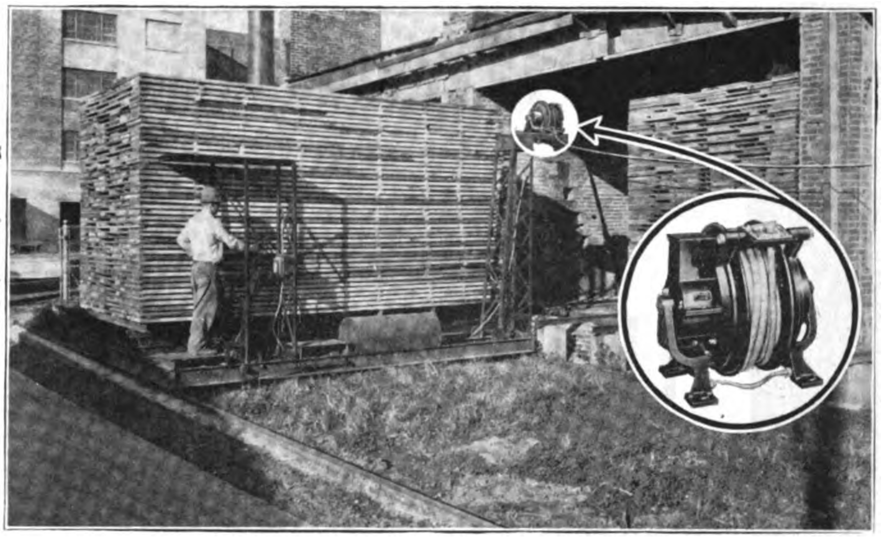
Electrical Measuring and Protective Apparatus

MAIN OFFICE:
229 Broadway, NEW YORK

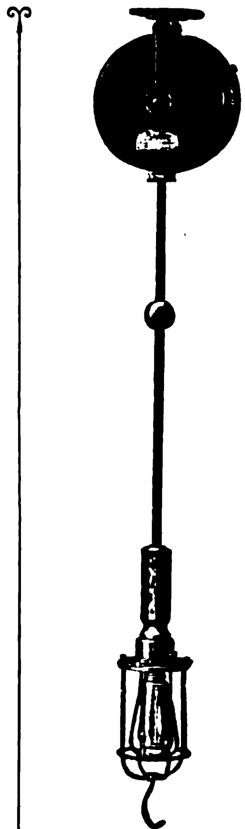
WORKS
Bethlehem, Penna.

Offices in Principal Cities in the United States and Canada.

Representatives in Australia, Cuba and Japan



Constant Duty Reelite with Ball Ring Cable Outlet as used in connection with electric power transfer car in use by Curtis Bros. & Co., Clinton, Iowa.



Reelite

The handy light on a reel
For use in the garage or machine shop where it is desired to bring the light directly to the work being done, without having the cord trailing about in the grease and dirt. Equipped with twenty-five feet of cord, and can be furnished with connector in place of light so that it will furnish current for small machinery, and portable drills, etc.

No lay-offs during cable repairs if you use Reelite

Power cable is so carefully handled, so perfectly coiled by Reelite, that it lasts two and three times longer than when it is left to take care of itself.

By eliminating cable renewals and delays arising from cable repairs, Reelite saves its cost in a brief space of time—often the first year.

There's almost no wear and tear—no cable lying around in the grease and dirt, to be run over by heavy wheels, caught on machinery, cut by sharp heels and tools. Reelite avoids all that—automatically.

Reelite pays out just enough cable for the job—never too little, never too much—and when slack occurs retrieves it on the instant.

Let us send you a copy of our illustrated bulletin 501-U which shows all types and sizes. No obligation. Just drop us a line.

APPLETON ELECTRIC COMPANY
1718 *Wellington Avenue, Chicago, U. S. A.*
New York—150 Varick St. Los Angeles—340 Azusa St.

CONSTANT DUTY
Reelite
REG. U. S. PAT. OFF.
Carries Current Where Needed

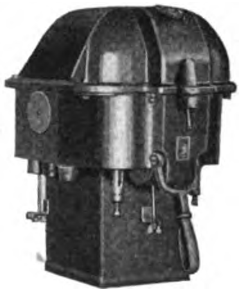
APPLETON ELECTRIC CO.
1718 Wellington Ave., Chicago
Gentlemen:
Please send us a copy of your new Bulletin 501-U, together with prices.

*Name*____________________
*Address*____________________
*City*__________ *State*__________

Moderate Capacity Oil Circuit Breakers

Made in types and capacities to meet every condition of operation. Manually and electrically operated, panel mounting or remote control, also for pipe frame, wall, pole and subway mounting.

We illustrate some of the more popular types:



Type F-10

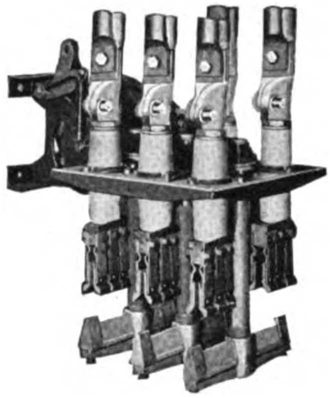
Type F-10

Manually operated, non-automatic and automatic for indoor service. Single throw. Capacities up to 200 amperes, 2500 volts, 300 amperes, 750 volts, alternating current. Interrupting capacity at 2500 volts, 2400 amperes.

The F-10 oil breakers are made only for wall mounting. They are drip, moisture and dust proof, and are particularly suitable for industrial application.

Type F-22

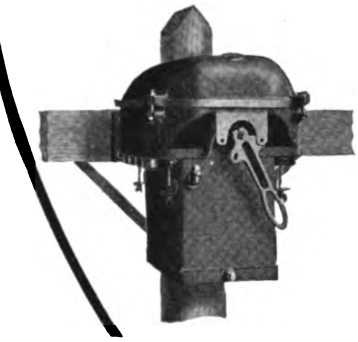
Manually and electrically operated, non-automatic and automatic for indoor service. Single and double throw. Capacities up to 600 amperes, 7500 volts, 800 amperes, 2500 volts, alternating current. Interrupting capacities at rated voltage 2500 to 9000 amperes.



Type F-22 Indoor, Three-Pole, Single-Throw 800 Ampere, 2500 Volt Oil Breaker Unit

Type FO-11

Manually operated, non-automatic, single-throw, 200 and 400 amperes, multi-pole. This breaker is designed with weather-proof fittings for general use in service in all weather conditions. The fittings are also dust-proof, rendering the breaker suitable for mill or mine service and for wall or pole mounting. The breaker is furnished 2, 3 and four pole.



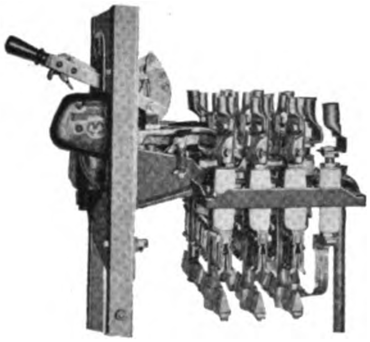
Type FO-11 Outdoor Oil Circuit-Breaker, Pole Mounting

Type FS-11

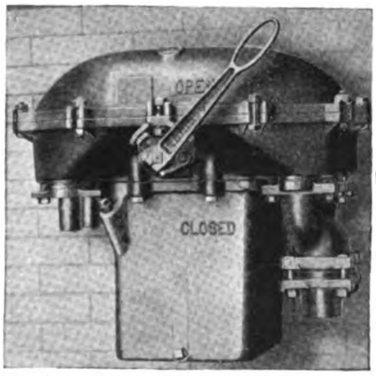
This breaker is similar to the FO-11, except that it is provided with a water-tight case for service subject to total immersion. It is furnished in 2 and 3-pole.

Type MF

This motor-starting breaker is manually operated for indoor service. Non-automatic starting position, automatic running position. Capacities up to 800 amperes, 2500 volts, alternating current. Interrupting capacities 1000 to 7200 amperes at service voltage. Type MF breakers are especially designed for starting in connection with auto transformers, 3-phase squirrel cage induction motors and self-starting synchronous motors. When properly applied, they protect the motor in the running position from heavy overloads and short circuits; and guard against the sudden application of full voltage to the motor after it has slowed down or come to rest following an interruption of power supply.



Type MF Motor Starting Circuit Breaker with Starting and Running Handles in Open Position.



Type FS-11 Oil Circuit-Breaker Subway Form

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

WESTINGHOUSE ELECTRIC

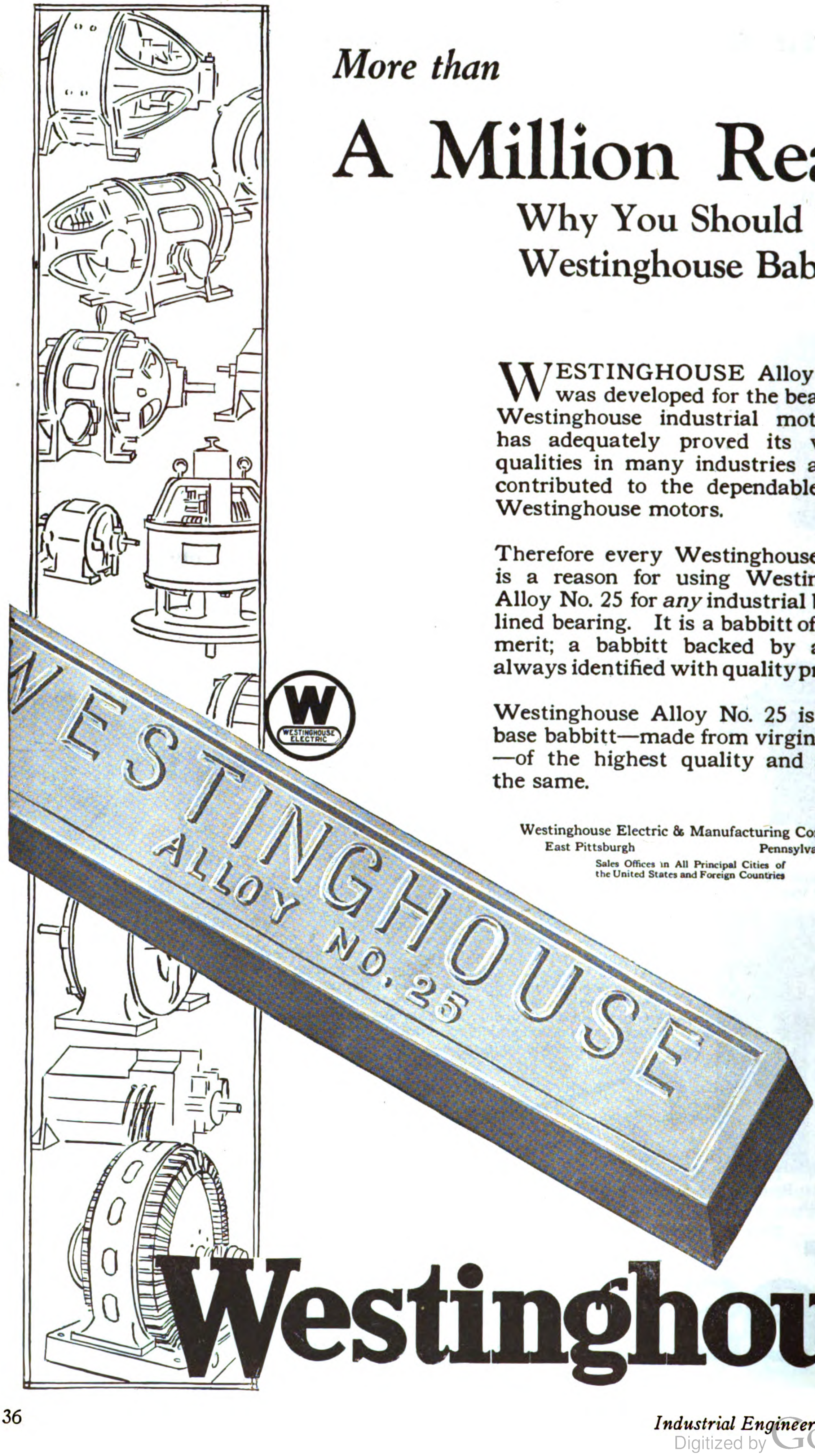
Westinghouse

X96626

More than

A Million Reasons

Why You Should Use Westinghouse Babbitt



WESTINGHOUSE Alloy No. 25 was developed for the bearings of Westinghouse industrial motors. It has adequately proved its wearing qualities in many industries and has contributed to the dependableness of Westinghouse motors.

Therefore every Westinghouse motor is a reason for using Westinghouse Alloy No. 25 for *any* industrial babbitt-lined bearing. It is a babbitt of proven merit; a babbitt backed by a name always identified with quality products.

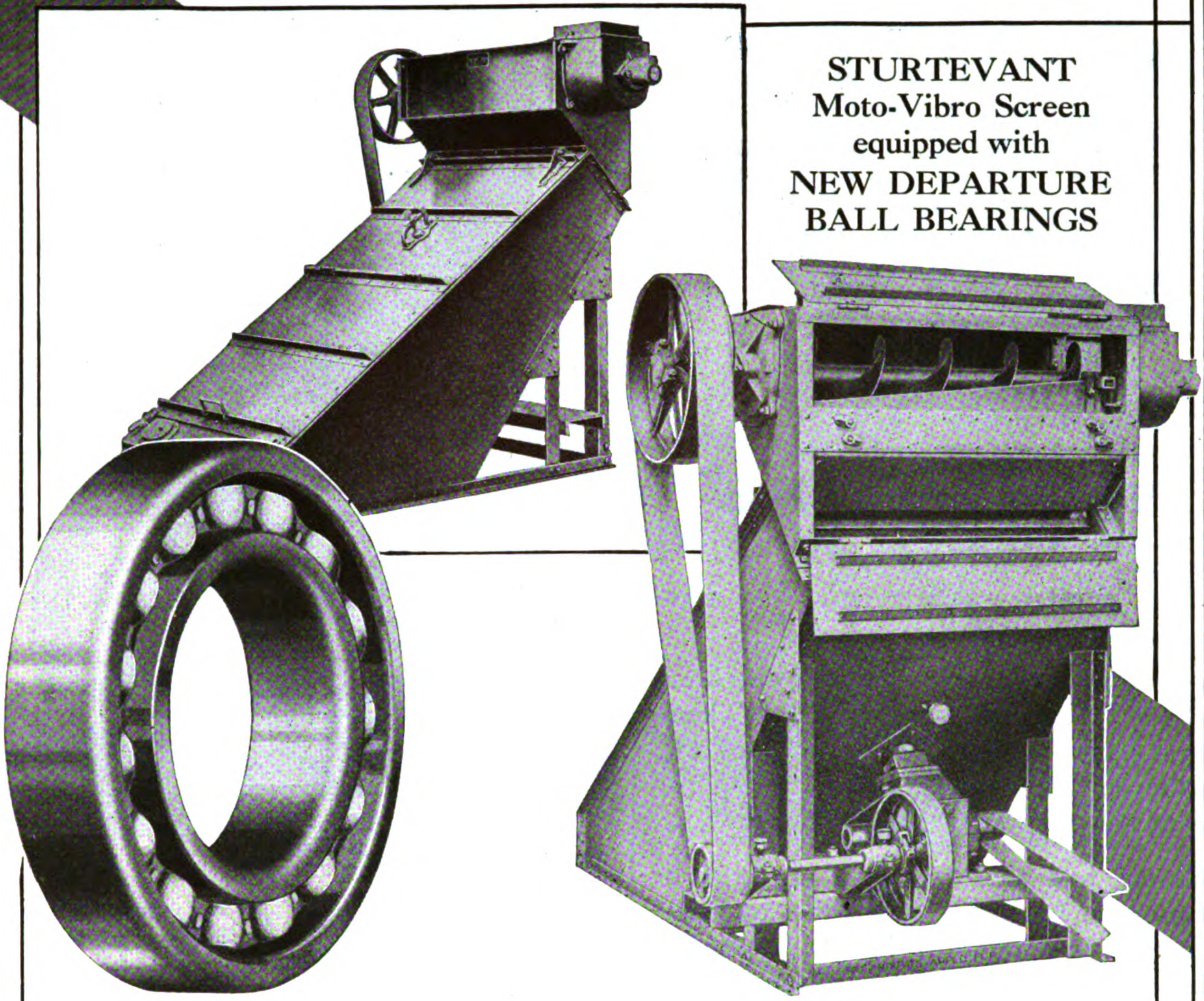
Westinghouse Alloy No. 25 is a lead base babbitt—made from virgin metals—of the highest quality and always the same.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

Westinghouse

X95595

STURTEVANT
Moto-Vibro Screen
equipped with
NEW DEPARTURE
BALL BEARINGS



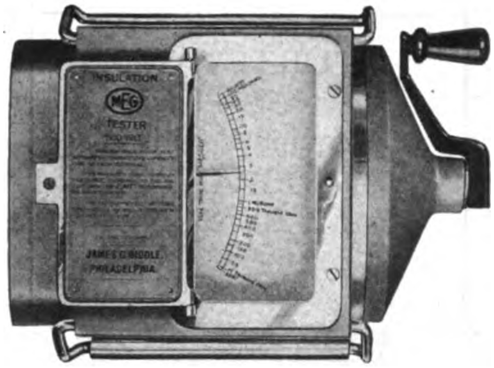
NEW DEPARTURES support vibrating and rotating parts without decentering and without measurable wear at all speeds and under peculiar conditions of high frequency such as occur in the vibrating mechanisms of the screen illustrated above.

New Departures can be mounted with lubricant-retaining, dust and dirt excluding closures and need only infrequent lubrication in small amounts. The application of New Departures to mechanisms such as this greatly reduces depreciation and maintenance cost.

Write for engineering data on "Ball Bearing Application to All Types of Machinery." Sent on request without obligation. Engineering counsel gladly furnished. The New Departure Mfg. Co., Bristol, Conn., Chicago and Detroit.

New Departure
Quality
Ball Bearings

600



Top View of
"MEG" Insulation Tester
Weight 6¾ lb.

"Megger" tests avoid expense of six electricians—

A certain oil refining company* operates a fleet of six sea-going oil tankers. When these ships are in port "Megger" tests are made on all important electrical equipment and accurate records are kept.

We are told that this plan of periodic inspection has made it possible to keep the electrical apparatus in such good condition that any necessary repairs can be made *in port*, and therefore it has been possible to omit an electrician from the crew of each boat while at sea.

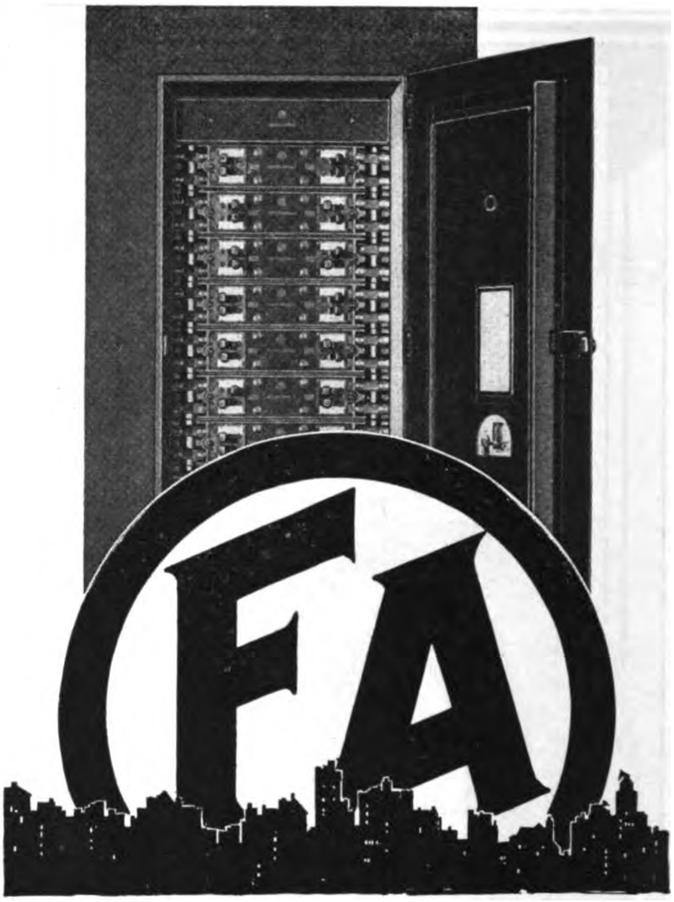
Such action *again* supports our well-founded claim that it "*pays*" to use "Megger" Instruments.

Pocket Manual of "Megger" Practice, No. 1150-W, containing 80 pages of helpful information and illustrations regarding the use of "Megger" Instruments, will be mailed upon request.

James G. Biddle
Electrical Instruments
1211-13 Arch Street, Philadelphia

"MEGGER"
TRADE MARK REGISTERED U.S. PAT. OFF.

*Name on request



Never on the "Sick List"

A man's ability to stay on the job is an index of his worth—so it is in the case of factory panelboards.

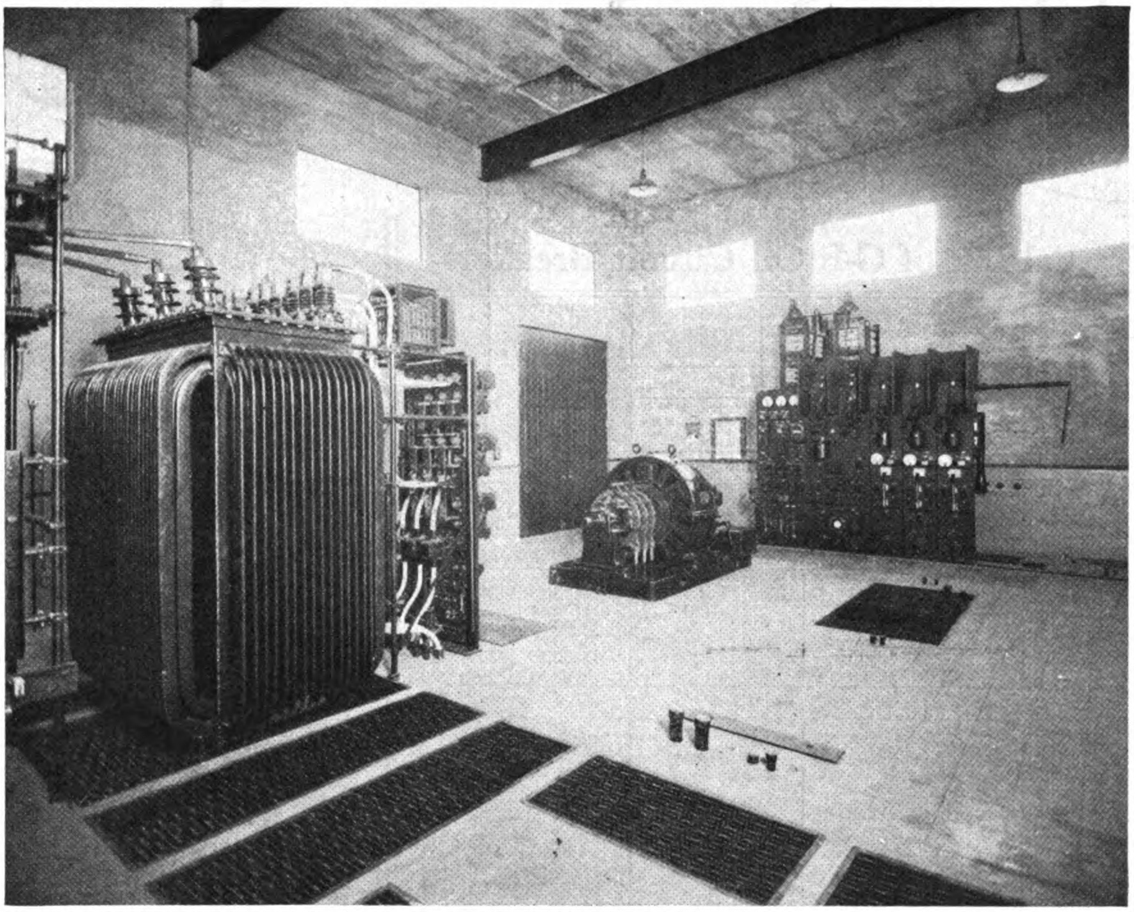
FA Panelboards do not require repair except in case of external accident—they are built and sold to give dependable service as long as the building lasts in which they are installed. Thoroughly standardized in every part and with the FA Steel Cabinet.

Send for the FA catalog—a complete data book on panelboards.

Frank Adam
ELECTRIC COMPANY
ST. LOUIS

DISTRICT OFFICES

Atlanta, Ga.	Cincinnati, O.	Memphis, Tenn.	Pittsburgh, Pa.
Baltimore, Md.	Dallas, Tex.	Miami, Fla.	San Francisco, Calif.
Boston, Mass.	Denver, Colo.	Minneapolis, Minn.	Seattle, Wash.
Brooklyn, N. Y.	Detroit, Mich.	New Orleans, La.	Toronto, Ont.
Buffalo, N. Y.	Kansas City, Mo.	Omaha, Nebr.	Vancouver, B. C.
Charlotte, N. C.	Los Angeles, Calif.	Philadelphia, Pa.	Walkerville, Ont.
Chicago, Ill.			Winnipeg, Man.



In the first full automatic railway substation in San Francisco

EVIDENCE of the ability of correctly chosen National Pyramid Brushes to stand not only normal loads, but prolonged overloads, is to be had in San Francisco. There the Market Street Railway Company has on San Bruno Avenue the first full automatic railway substation to be erected in that city. It is equipped with a 750 Kw., 600-volt, 1250 r.p.m. rotary converter. This machine operates at 75 per cent of its rated capacity, except during the rush hours. Between 7.30 and 9 in the morning and 4 and 6 in the afternoon the converter carries 100 per cent overload.

National Pyramid Grade 259 was supplied as original equipment on the DC side of this machine, and is carrying not only the normal loads but also the overloads with practically sparkless commutation.

National Pyramid Grade ET-10, on the AC side, was also part of the original equipment.

Our Sales Engineers are at the service of both manufacturers and users of electrical equipment. In many cases they have been able to end vexing brush troubles; and in others to add to the capacity and utility of equipment. Write, wire or phone and the experience of these men will be put at your disposal.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide UCC *and Carbon Corporation*

Cleveland SILVER STRAND CABLE TRADE MARK REGISTERED San Francisco

Emergency Service Plants are located in

CHICAGO PITTSBURGH NEW YORK, N. Y. BIRMINGHAM

Weigh the value of

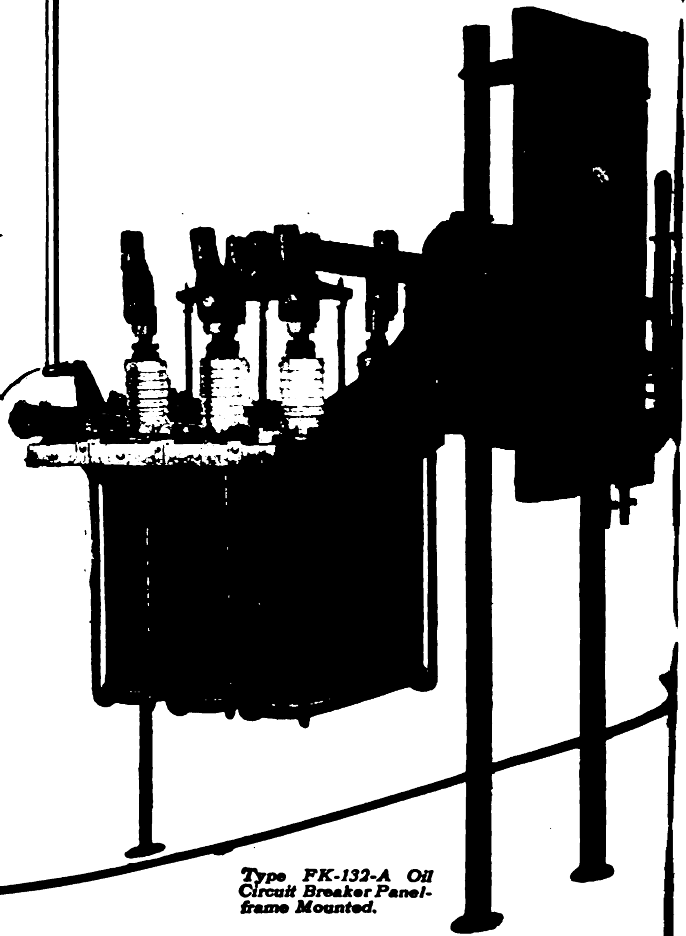
A Partial List of G-E Oil Circuit Breakers

TYPE	Voltages	Current-Carrying Capacities	Interrupting Capacities (Amps. at rated volts)
INDUSTRIAL TYPES			
FP-115	110 to 550	50	400 to 500
FP-110	110 to 550	50	400 to 500
FK-20	2500	60 to 300	1300 to 1650
MANHOLE AND POLE TYPES			
FP-104	7500	200	240
FP-7	4500 to 15000	100 to 200	240 to 400
FKO-37	15000 to 37000	400 to 600	1000 to 1500
SWITCHBOARD TYPES			
FK-13	3300	200	1750
FK-5	600 to 7500	200 to 800	1400 to 15000
FK-35 and 35Y	600 to 7500	400 to 800	1700 to 20000
FK-12	15000	300 to 800	1000
FK-12B	4500	1500	4000
FK-132A and B	7500 to 15000	400 to 1200	1500 to 5300
FK-32C	7500 to 15000	600 to 1200	3600 to 8300
STATION TYPES			
FK-34A	4500	2000	6500
FK-25	600 to 2500	3000 to 5000	7200 to 30000
FK-53B	15000 to 25000	400 to 2000	2200 to 4600
FK-54	7500	600 to 1600	10500
FH-103, 203	7500 to 35000	500 to 2000	4700 to 32000
FH-206, 209	7500 to 35000	500 to 4000	6700 to 69000
FHD-17	15000	600 to 5000	32000
FHD-21	15000	600 to 4000	50000
FK-230A	15000 to 25000	600 to 3000	10700 to 30000
FHK-230B	15000 to 37000	600 to 3000	18500 to 60000
FK(O)-136A	25000 to 110000	400 and 800	1200 to 2300
FK(O)-236A	15000 to 73000	400 and 800	2000 to 7000
FHK(O)-236B	15000 to 88000	600 to 1200	3300 to 14000
FK(O)-39A	110000 to 154000	800	2600 to 3300
FHK(O)-39B	15000 to 220000	600 to 2000	2600 to 30000
FHK(O)-39C	15000 to 220000	600 to 2000	3900 to 38000

There's a G-E Breaker for every application

Oil Circuit Breakers

-part of the complete line of General Electric equipment to control and protect power generating and distributing apparatus.



Type FK-132-A Oil Circuit Breaker Panel-frame Mounted.

GENERAL

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

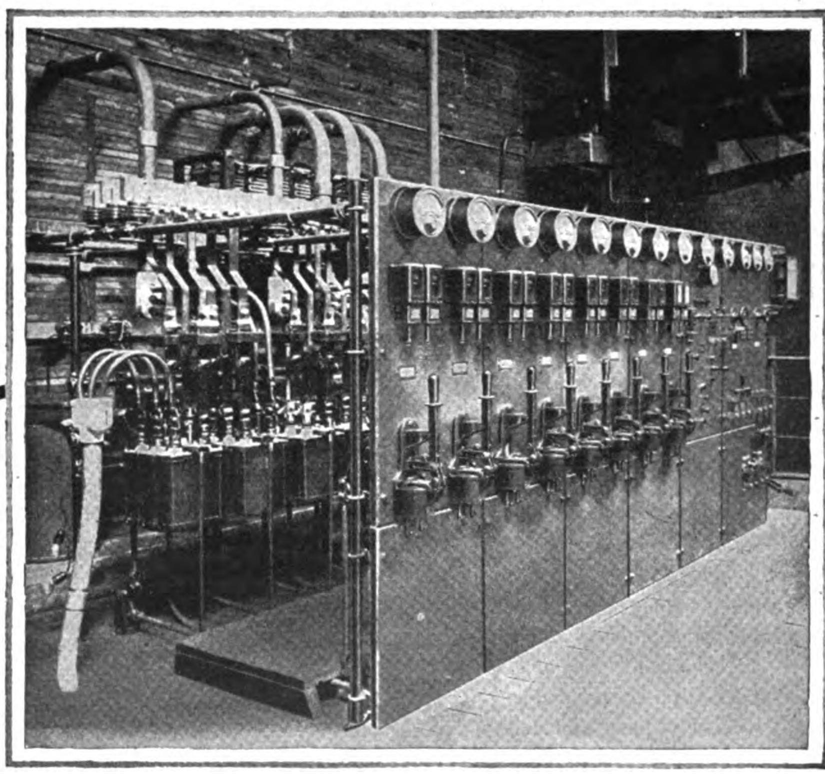
32 years' experience

Thirty-two years of design and manufacturing are back of every General Electric Oil Circuit Breaker built today.

Since 1895, when this Company constructed the first oil circuit breaker used commercially in this country, breaker after breaker has been manufactured to meet the ever-changing and increasing requirements of a rapidly growing electrical industry.

During these years there have been developed those requisites of successful oil circuit breaker engineering—research, testing facilities, and analysis of problems by operating and designing engineers with experience in actual installations.

Experience is one of the most important reasons why you will receive long-lived and satisfactory service from every G-E Oil Circuit Breaker.



Type FK-35 Oil Circuit Breakers, Donovan Lumber Company, Aberdeen, Washington

470-2

ELECTRIC

SALES OFFICES IN PRINCIPAL CITIES

Engineered Units – Stock Prices

FALK Speed Reducers are standardized for any duty. New rating tables make selection of the unit easy. Shipment is made from stock on standard ratios — immediately!

Falk Speed Reducer rating tables are a guarantee of capacity. Provision is made for 100 per cent overload starting capacity.

Purchasing departments and engineers should have price lists and bulletin on these new units.

Get Falk quotations on your present requirements for comparison.

Bulletin Number 160, containing rating tables and full dimensions, with new price lists, sent on request.

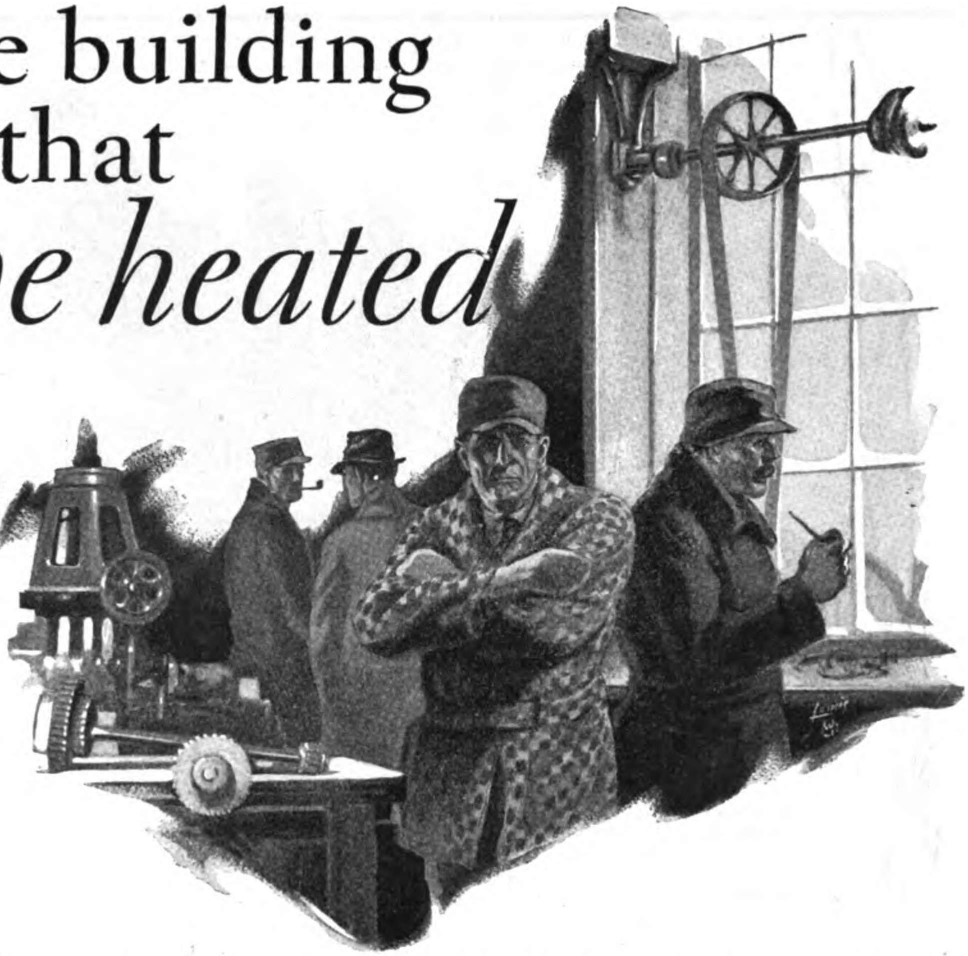
The Falk Corporation

New York Albany Wilkes-Barre Pittsburgh Birmingham **Milwaukee** Detroit Chicago Denver San Francisco Portland Minneapolis

Canada: The William Kennedy & Sons, Ltd., Owen Sound, Ontario
Exclusive Sales Representatives & Licensed Manufacturers under Falk Patents
Branches: Halifax, Montreal, Toronto, Cobalt, Winnipeg, Vancouver

Falk Herringbone Gears | *Falk Speed Reducers* | *Falk Flexible Couplings*

For the building that *Can't be heated*



For the building "too old" to be heated—for the mammoth amphitheatre that simply "can't" be heated—for the temporary structure that wasn't even built to be heated—for the new modern plant with acres of floor space, thousands of windows, high ceilings, and crane housings, there is the Venturafin Method of Unit Heating.

Some of the many benefits of the Venturafin Method of Unit Heating are heat control—the elimination of cold spots—a complete air circuit—heat losses reduced to a minimum—and a more even distribution of heat. It is ideal, too, as an auxiliary unit for cold corners and out of the way places.

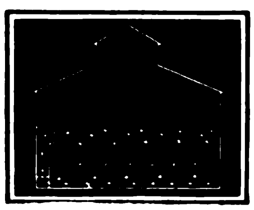
Venturafin gives more than five times the efficiency of steam coils, radiators, etc.—has 1/10 the weight—occupies 1/4 the space—costs less than ordinary radiation, and can be employed wherever steam is available. Over 15,000 in use.

Mail the coupon today—no obligation **—or ask your heating contractor for the facts on Venturafin.**

AMERICAN BLOWER CO., DETROIT
BRANCH OFFICES IN ALL PRINCIPAL CITIES
CANADIAN SIROCCO CO., LTD., WINDSOR, ONT.

Venturafin consists of the following major parts: (1) Copper fin-heater—with five times the radiating efficiency of ordinary iron coils, (2) The famous American Blower Ventura Blower (electrically driven), (3) Air recirculating box.

Diagram shows the general tendency of heated air to rise from radiators, steam coils, etc.



This diagram shows an ideal heating system the principle of which is applied in the Venturafin Method.

COUPON
AMERICAN BLOWER CO., DETROIT, MICH.
Send details relative to the application of (6)
The Venturafin Method of Unit Heating to

*Name*____________________
*Address*____________________
*City and State*____________________
*Type and size of building to be heated*____________________

(632)

American Blower

"Sirocco" VENTILATING, HEATING, AIR CONDITIONING, DRYING, MECHANICAL DRAFT
Manufacturers of all Types of Air-Handling Equipment —— Since 1881

HEAT WITH UNIT HEATERS

THE OHIO CARBON COMPANY EXTENDS TO YOU BEST WISHES FOR 1928!

Lazy Brushes—
mean LOST POWER!

Carbon Brushes can be lazy, indifferent to their work—good enough to "get by." Apparently giving perfect commutation, from all appearances a well made product, the brush may be putting the burden of its service on some part of the machine not intended to carry the load.

On test, the brushes you investigate before buying, may give excellent service and measure up to all of your requirements. But, how well do they function in the long run of practical use?

Brushes can be made to meet specifications—or there can be added that "something extra" which costs a little more to produce, but saves the maker and the user any future troubles.

OHIO BRUSHES have that *something extra.* Shunts that are just a little stronger, shunts in which repeated temperature variations will not change the low voltage drop of the connection,—ample and uniform copper coating,—hardness accurately determined—brushes containing the highest grade of graphite or metal for conforming with the operating speed or carrying capacity requirement of specific motors.

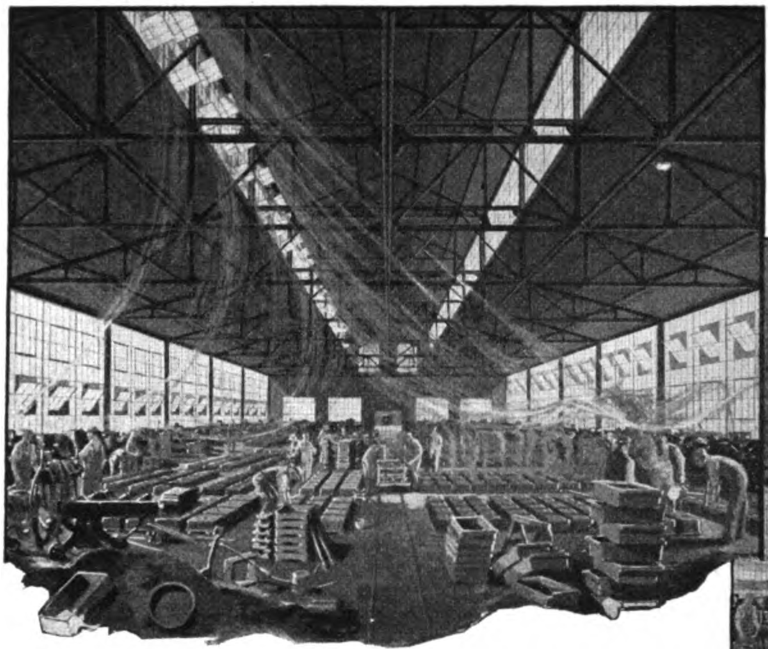
Include Ohio Carbon Brushes in your next replacement order. You will be satisfied with their performance for there's never a lazy one.

THE OHIO CARBON COMPANY
8215 Almira Avenue, CLEVELAND, OHIO

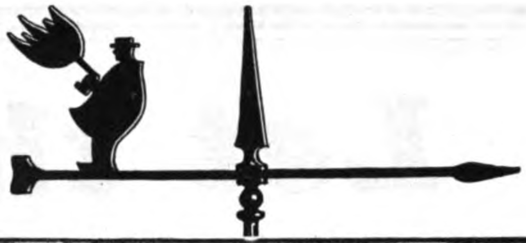
A few of the brushes in our Catalog No. 16. It is full of useful data. Have you a copy?

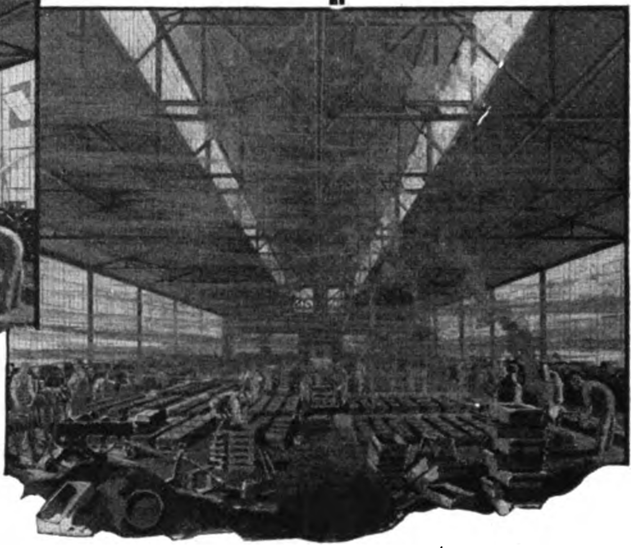
"From raw material to finished product"

OHIO CARBON BRUSHES



Sidewall windows open on both sides.
Monitor windows open on leeward side.





Sidewall windows closed. Monitor windows open on windward side.

How do open windows affect ventilation?

What is the measure of the air which will flow in and out of a building due to the buoyancy of the warmer inside air?

How do size and location of window openings affect possible air changes?

Is the direction of the prevailing wind a factor in natural ventilation?

Under what conditions is the effective flow of air in and out of a building assisted by the motive force of the wind? When is it hindered?

When you are making plans for new buildings—in advance of construction—these questions and many others deserve your serious consideration.

As a result of many experiments with models and tests in actual industrial buildings, our Department of Engineering Research has developed methods by means of which just such questions can be answered with considerable accuracy. By filling out the blank below you can have the benefit of this research work—without obligation.

Ask Fenestra

DETROIT STEEL PRODUCTS COMPANY · 2230 East Grand Boulevard · DETROIT, MICH.

What can you tell me about the different methods of ventilating the building described below?

Type of building contemplated: Single Story .... Multi-story ....

To be used for .... Length .... Width .... Height ....

Note: If possible, send tentative plans, elevations, sections or sketches showing size and location of all proposed windows with sill heights, together with any additional information which would have a bearing upon the design of the structure to be erected.

Name of Company .... Your Name ....

Address .... City .... State ....

Let these facts sink in!

1. The Pulmax Drive has no harmful effect whatever on any first quality, pliable waterproof leather belt. We can prove this to you as we have to hundreds of Pulmax users.

2. The Pulmax Drive is more efficient, economical, dependable, and inexpensive to operate and maintain than any other drive.

Every motor you put in is an opportunity for a Pulmax Drive.

Ask us to prove it.

BIRD MACHINE COMPANY
South Walpole, Massachusetts

BOSTON
Bird Machine Company
179 Lincoln Street

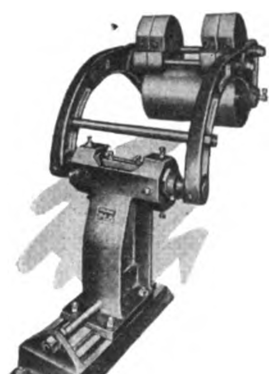
NEW YORK
The Power Transmission Co.
173 Lafayette Street

CHICAGO
Chicago Belting Co.
113 N. Green St.

CLEVELAND
Cleveland Tool & Supply Co.
1427 West Sixth St.

NEW HAVEN
The Arthur C. Morse Co.
152 Temple St.

ST. LOUIS
The Teuscher Pulley & Belting Co.
801 No. Second St.

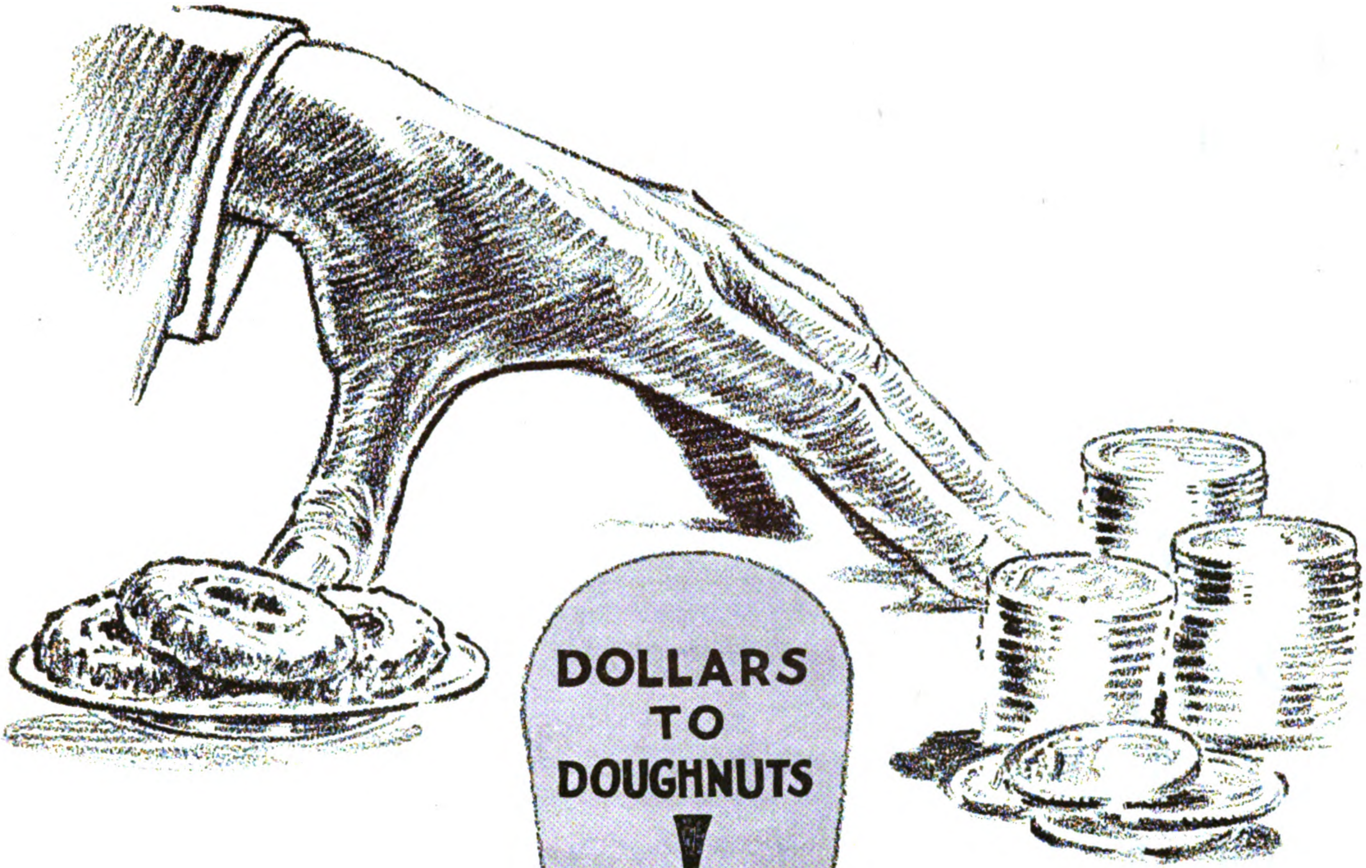


There is a standard Pulmax Drive for all widths of belt covering drives from 1 to 1500 H.P.

Send for free copy of this up-to-the-minute analysis of transmission. You'll find it valuable and useful.

Pulmax Drive

1470



DOLLARS TO DOUGHNUTS

In a small room in the city of Rochester, more than 75 years ago, there began a business specializing in the manufacture of precision thermometers. And, by adhering strictly to this fundamental principal of specialization, in unfailing accuracy, the Taylor Instrument Company has developed, through scientific research and study, into an institution of highly specialized manufacturing units, anticipating, as it has, every need of industry, the professions, the arts, and the home for indicating, recording, and controlling temperature and pressure instruments.

This vast institution offers to industry 8,000 styles of *Tycos* Instruments—each designed to do a definite job, each carrying with it the unqualified guarantee of the Taylor Instrument Companies for reliability and precision.

Taylor Instrument Companies
Rochester, N. Y., U. S. A.
CANADIAN PLANT, *TYCOS* BUILDING, TORONTO
Manufacturing Distributors in Great Britain: Short & Mason, Ltd., London.

Tycos
Temperature Instruments

REG'D. TRADE MARK *Tycos* ROCHESTER, N.Y.

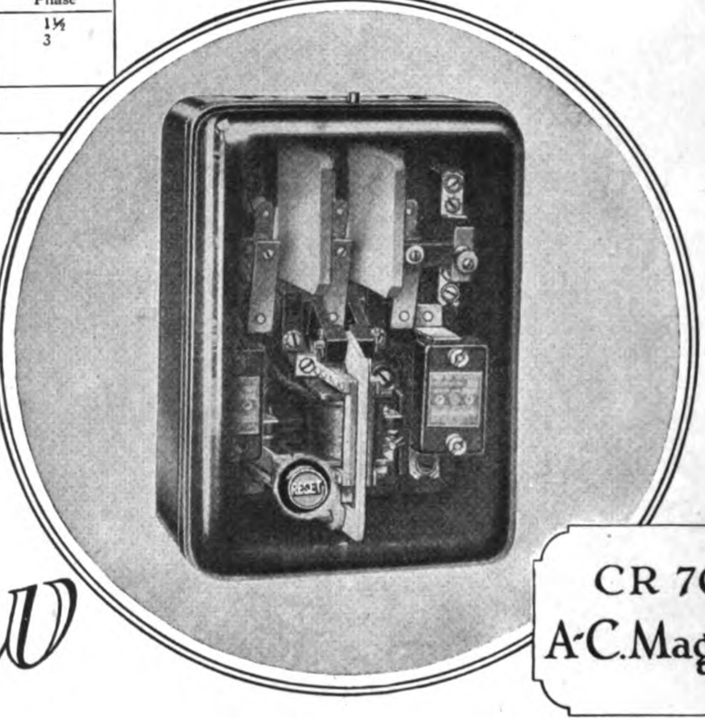
INDICATING—RECORDING—CONTROLLING

Tycos THE SIXTH SENSE OF INDUSTRY

RATINGS

Volts	Squirrel-Cage or Slip-Ring	Single-Phase
110	3	1½
220	5	3
440	7½	
550/600	7½	

Switch can be used with push-button, thermostat, pressure governor, float switch, etc.



CR 7006-D26
A-C. Magnetic Switch

A New Unbeatable Combination of Size · Rating · Price

The CR7006 line of magnetic switches has always been the most popular in the industry. The "D26" is the newest—and smallest—of this famous family.

Ask your nearest G-E office to show you the "D26" as soon as possible—for nothing will be so convincing as an inspection. Notice:

The neat, uncrowded, accessible arrangement of parts—all finished in black and silver, and enclosed in a handsome drawn-shell case.

The small size—6¾ in. wide, 5 in. deep, 9 in. high.

The rating—well able to throw a 7½-h.p., 440- or 550-volt motor across the line.

The contactor—double break; strong; fast-moving; operated by a high-speed solenoid; contacts of silver—all combining to give a very high interrupting capacity.

The overload protection—two simple, accurate, hand-reset relays with interchangeable heaters for interchange of ratings.

The price—well below any similar combination of size, rating, and appearance.

301-23

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN PRINCIPAL CITIES

—and quietly

Easy going is the load that rides on Bassicks—

No more jolting—jumping or stalling. No more screeching casters—or grunting trucks—for Bassicks roll easily—turn easily—ride smoothly—and deliver the load quickly—safely—and on schedule.

Bassicks work for the management—and "team" with the worker—always.

—How easily it rolls on Bassicks'

BASSICKS
Harvard Steel Ball-Bearing Truck Casters

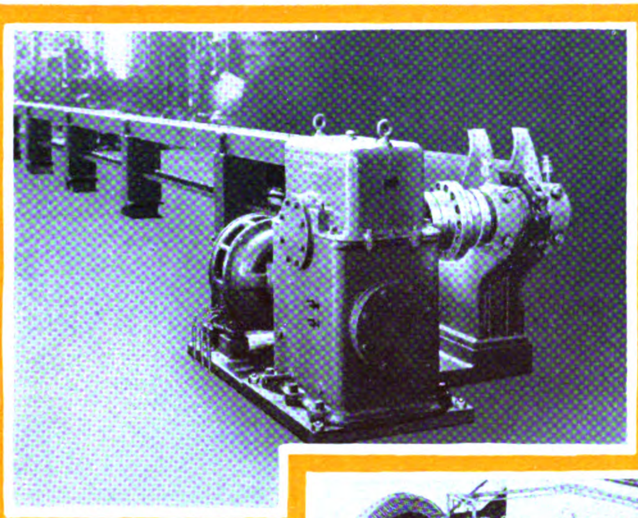
Heavy gauge steel construction. Sturdy ribbed iron wheels. Embossed top plate, reinforced by independent ball cup—gives double thickness of metal and double strength at vital points.

Lapped ball bearings. Specially annealed, extra heavy king pin.

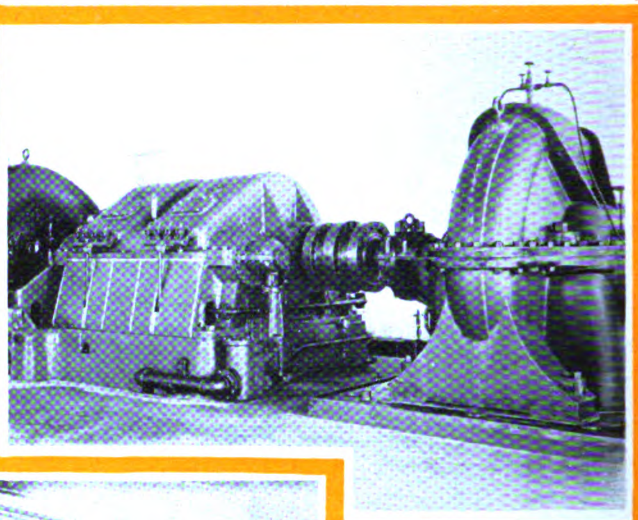
Spanner bushing, riveted solid between forks of horn protects axle, strengthens horn, prevents its bending inward under weight and binding wheel; gives larger bearing surface for wheel with resultant longer life. (Bulletin No. 104-F on request.)

BASSICK Casters
Reg. U. S. Pat. Off.
The BASSICK COMPANY
(A Division of Stewart Warner)
BRIDGEPORT, CONN.

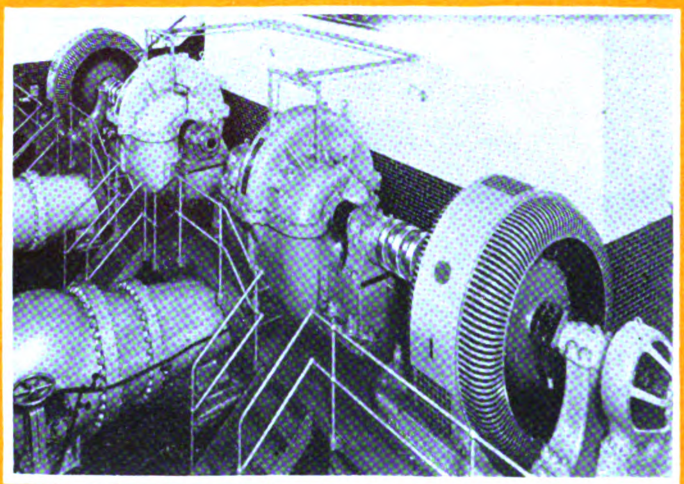
For thirty-one years the leading makers of Better Casters for home, office, hotel, hospital, warehouse and factory.



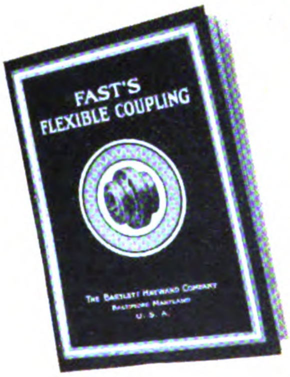
Fast's Flexible Coupling. 10,000 lb. Chain Draw Bench. 20 H. P. at 35 R. P. M. Rome Brass & Copper Company, Rome, New York



Fast's Flexible Coupling, on a Turbine-Driven Pump through Reduction Gears. Metropolitan Utilities District, Omaha, Nebraska



Fast's Flexible Couplings. Motor-Driven Pumps. 2600 H. P. at 514 R. P. M. City of Detroit, Pumping Station.



Write for this
NEW CATALOG
of a Flexible Coupling without Flexible Materials.

THE BARTLETT HAYWARD CO.
SCOTT and McHENRY STREETS - BALTIMORE, MD.

BIRMINGHAM, ALA.
S. C. Ebbert
321 Brown-Marx Building

BOSTON
H. W. Calder
10 High Street

CHICAGO
Bartlett Hayward Company
326 W. Madison Street

DENVER
Lindrooth Shubart & Company
Boston Building

HOUSTON, TEXAS
M. N. Dannenbaum
Bankers Mortgage Building

KINGSTON, PA.
Ralph A. Wheeler

LOS ANGELES
Thomas Machinery Company
American Bank Building

NEW YORK
Bartlett Hayward Company
Pershing Square Building

PHILADELPHIA
Jas. M. Jenkins
Ins. Co. of North America Bldg.

PITTSBURGH-CLEVELAND DIST.
Bartlett Hayward Company
Oliver Building, Pittsburgh

SAN FRANCISCO
Oliver B. Lyman
Call Building

MONTREAL
Fraser & Chalmers of Canada, Ltd.
Canada Cement Building

Special Type
COUPLINGS

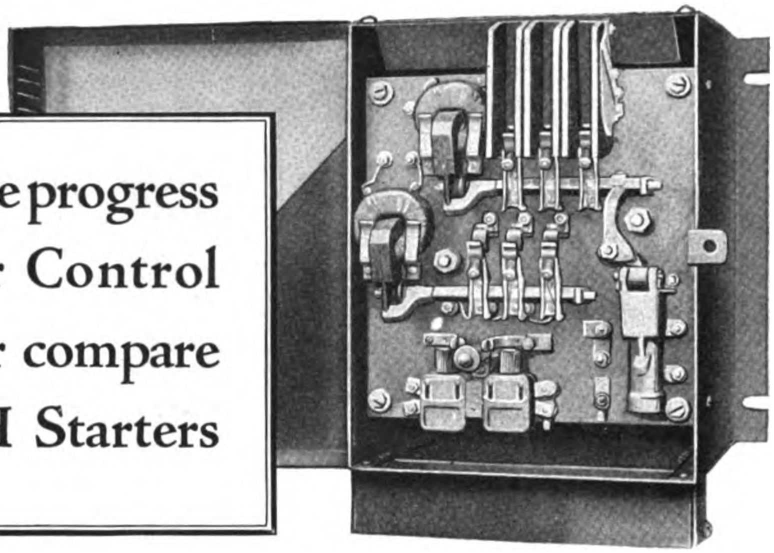
FAST'S FLEXIBLE COUPLING may be had in special types, variations of the standard design, but retaining all the features of perfect mechanical flexibility. If you have some special drive requiring a special type of flexible coupling to compensate for unusual shaft misalignment, or to allow free end float, or other special requirements, write us. Give shaft sizes. Send a drawing if possible. If one of the standard variations is not adaptable, our Engineering Department can design the proper type of FAST'S COUPLING to meet your unusual requirements.

See Preceding Page

FAST'S FLEXIBLE COUPLING


Noark
NOARK
INDICATING
600 VOLTS 30 AMPS
UND.LAB. INSPECTED
CAT. NO. 4614
There is no advantage in using cheap fuses to guard against destructive overloads. The cost of renewing even a simple circuit — to say nothing of the expense of rewinding the armature of a motor — is always far greater than anv difference in price of a fuse.
Look for the "Un. Lab. Inspected" label on every fuse you buy. It is your first insurance of a good fuse.
But if you would make assurance doubly sure and know beyond the shadow of a doubt that every sentinel you set to guard your electrical installations will not fail in point of alertness and dependability, see that the name
NOARK
too, is on everv fuse you buy.
Noark fuses, ferrule or knife blade types, renewable or non-renewable, indicating or non-indicating, all are made to
"Blow on the Dot"
and—when used according to their indicated capacities—it is physically impossible for them to fail to do their duty.
COLT'S PATENT FIRE ARMS MFG. CO.
Electrical Division
NOARK
COLT
HARTFORD, CONN. U.S.A.
NEW YORK ~ BOSTON ~ CHICAGO ~ SAN FRANCISCO
33-F-10

For You Men Who Want Facts



To determine the progress in A.C. Motor Control for the last year compare these new C-H Starters

The new C-H Primary Resistor Starter (Bul. 9605) is illustrated. More than a score of features merit your consideration. Write for full information on all new A.C. Starters.

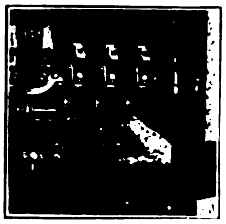
THE new C-H Automatic Starters were designed "under fire". Years of service were crowded into weeks of merciless testing. As failures occurred, part after part was redesigned, retested, redesigned and again retested until the standard *of millions of operations* was achieved.

Millions of operations—such Motor Control service your plant, most likely, will never demand—but the inbuilt dependability and slow depreciation the C-H standard insures, mean big savings in operating and maintenance charges.

Specify Cutler-Hammer for your very next A.C. Automatic Starter installation. Check over the features. Watch it in service. You, too, will say "Nothing else but C-H after this!"

The CUTLER-HAMMER Mfg. Co.
Pioneer Manufacturers of Electric Control Apparatus
1219 St. Paul Avenue
MILWAUKEE, WISCONSIN

Check these exclusive features!

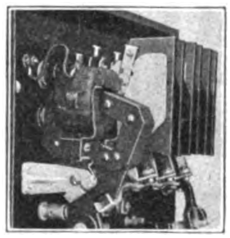


1 Thermal Overload Protection. Cuts motor from line only when heating of motor windings becomes dangerous. Easily reset from outside of case.

2 Overload relay easily adjustable to insure maximum output from motor without danger to windings.

3 Thermal Overload Relays easily and quickly reset from outside of starter case.

4 Double pull solenoid type magnet. Quick, powerful, positive pull insures full roll-and-rub contact action. Cool operation of contacts and freedom from pitting assures long life.



5 Magnet coils easily demountable. Saves valuable time in replacing coils injured by abuse or accident.

6 Hardened and ground steel bearings used for switch mechanism. Adjustable to compensate for wear through years of steady service.

7 Every starter part designed for quick replacement. This is most valuable service insurance—constant protection against shut-downs, even in the face of abuse to the starter.

8 Chimney type arc shields and heavy blow-out coils quickly carry arc away from contacts, greatly increasing their life. Note simple removal of arc shields.

CUTLER-HAMMER

Industrial Efficiency Depends on Electrical Control

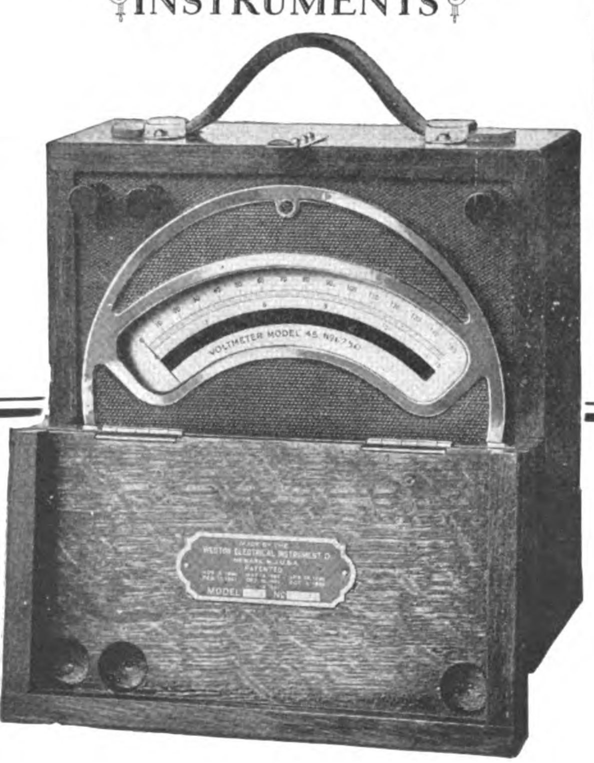
In Life-long Partnership with "WESTONS"

WESTON has been far more than a mere *supplier* to the Electric Power Industry during the past forty years. By invitation, we have been privileged to sit in its inner councils, developing the necessary instruments to serve its needs, step by step, throughout the *entire period* of its history. The industry in all its branches—laboratory, manufacturing and power equipment operation—has brought its various testing problems to us to be solved. Our mutual relations have been more like a partnership, in which Weston's responsibility has ever been *extreme accuracy and reliability of the test result.* This explains why the second and third generations of engineers are reluctant to experiment with other instruments.

Model 45 D. C. Portables are recommended for general industrial testing. They employ the same principles of design as the original Westons—famous for forty years. Accuracy, ½ of one per cent. Thoroughly shielded and built into a strong wooden carrying box. Knife-edge pointers and mirror scales. Made as Voltmeters, Ammeters, Millivoltmeters and Milliammeters.

WESTON ELECTRICAL INSTRUMENT CORP.
136 Weston Avenue, Newark, N. J.

Weston
PIONEERS SINCE 1888
INSTRUMENTS



SORGEL Air-Cooled Transformers

7½ kva. Single Phase Lighting Transformer

Prompt deliveries on standard types in sizes ½ to 50 K.V.A.

Sorgel Air-Cooled Transformers are neat and compact. All self-contained in a single unit. They require no additional conduit cutting, and fit right into the cabinet. They are simple to install, and cost less over a period of years.

Transformers designed for Special Applications.

Many desirable industrial applications for these transformers, such as:—

110 volt lighting from 550-440-220 volt.

Power changes—2 to 3 phase, 550 or 440 volt to 220 volt, etc.

Heat treating furnaces.

Series lighting systems.

Voltage boosters or adjusters.

Electric Welding—and many other special apparatus.

Send for our Bulletin No. 1027.

Sorgel Electric Company

91 W. WATER ST., MILWAUKEE, WIS.

NEW and IMPROVED

TRICO
REG. U S PAT. OFF.

"Famous For Performance"

RENEWABLE FUSES

Ferrule type—Only 2 parts and the TRICO Powder-Packed Renewal Element.

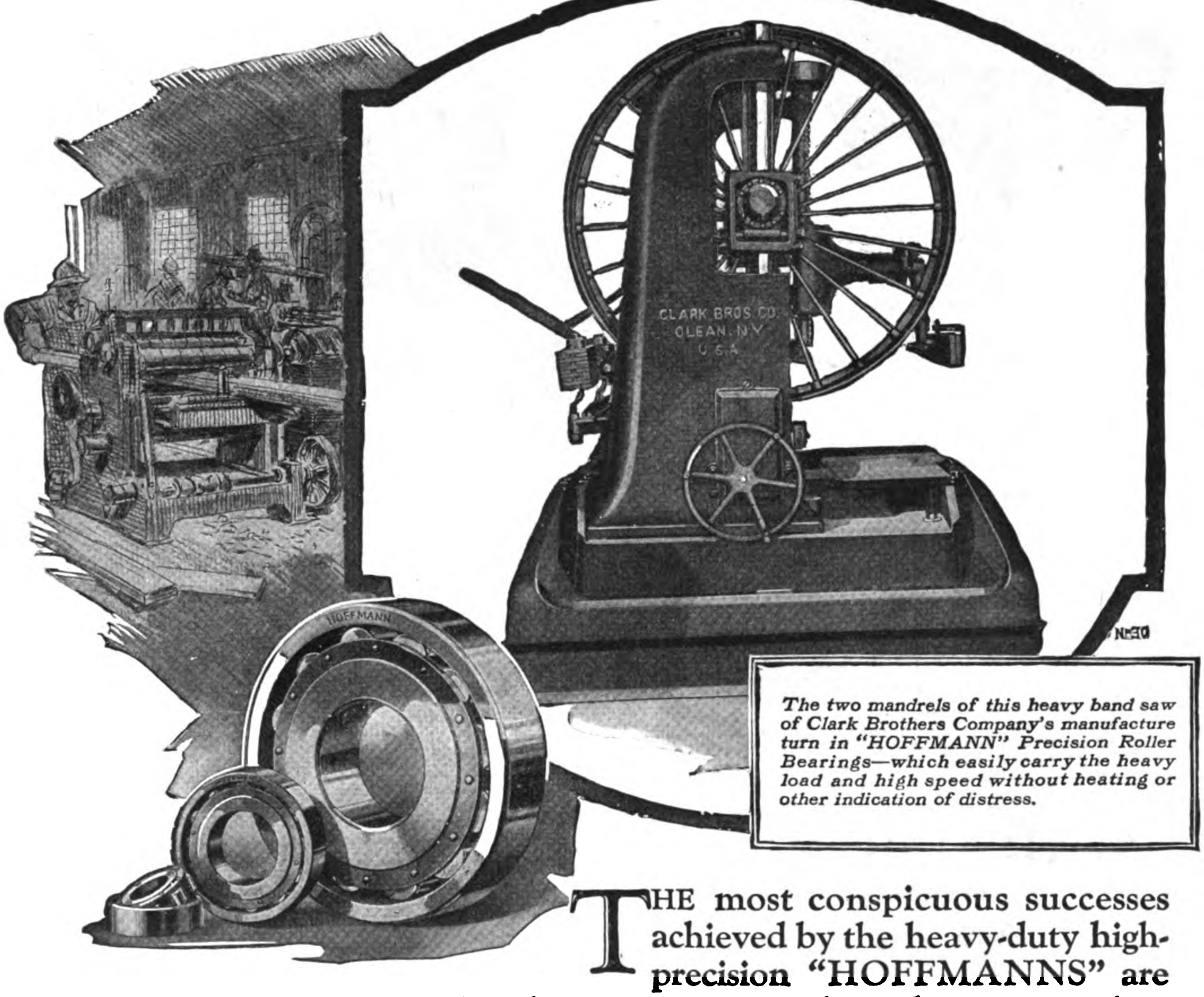
Knife Blade type—Only 3 parts and the TRICO Powder-Packed Renewal Element.

No Small Parts—Durable Construction
They're "POWDER-PACKED"

A request, on your firm's letterhead, will bring free samples—no obligation.

TRICO FUSE MFG. CO.

Makers of High Grade Fuses since 1917
1002 McKinley Ave., Milwaukee, Wis.



The two mandrels of this heavy band saw of Clark Brothers Company's manufacture turn in "HOFFMANN" Precision Roller Bearings—which easily carry the heavy load and high speed without heating or other indication of distress.

THE most conspicuous successes achieved by the heavy-duty high-precision "HOFFMANNS" are those many cases where they are standing up successfully under conditions which caused the failure of all bearings previously used. This, obviously, means an exceptional factor of safety available, in the "HOFFMANN," for service less arduous but still in the heavy-load class.

Let us send Catalog 904.

NORMA-HOFFMANN BEARINGS CORPORATION
STAMFORD, CONN. · · U. S. A.

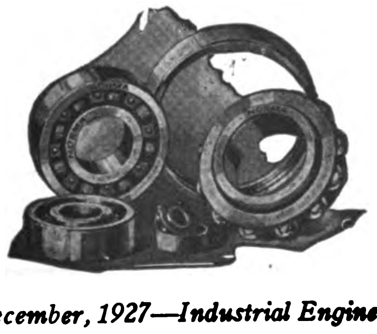
NB-870

CHICAGO POWER SHOW FEB. 14-18

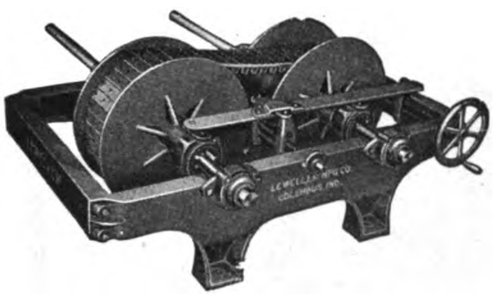
"NORMA"
PRECISION
BALL BEARINGS

In both open and closed types and in all standard sizes offer, for the lighter bearing duties, the obvious advantages of high-precision quality.

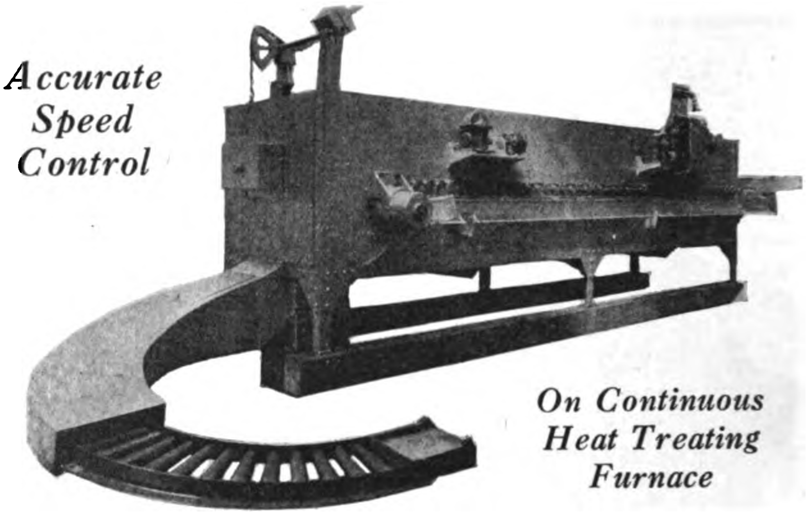
Catalog 905 describes them.



"HOFFMANN"
PRECISION
ROLLER BEARINGS



Accurate Speed Control



On Continuous Heat Treating Furnace

LEWELLEN TRANSMISSION UNIT

Speed control is an absolute necessity on this Metal Equipment Company Electric Continuous roller hearth furnace, used in the treatment of automobile springs at the

L. A. Young Industries, Inc.

plant in Detroit.

With a LEWELLEN variable speed transmission, speed changes from 7 minutes to 35 minutes are obtained. A speed indicator indicates the relative speeds, enabling the operator to duplicate exact heating conditions on various material treated.

LEWELLEN Transmissions do not jerk. Speeds can be varied from slow to fast and fast to slow gradually as required.

Write for the LEWELLEN catalog.

There are thousands of applications of LEWELLEN Variable Speed Transmissions. Every manufacturing process needs this flexible speed control.

LEWELLEN
Variable Speed
TRANSMISSION

LEWELLEN MFG. CO., 1300—10th STREET, COLUMBUS, IND.

MARTINDALE Motor Maintenance **EQUIPMENT**

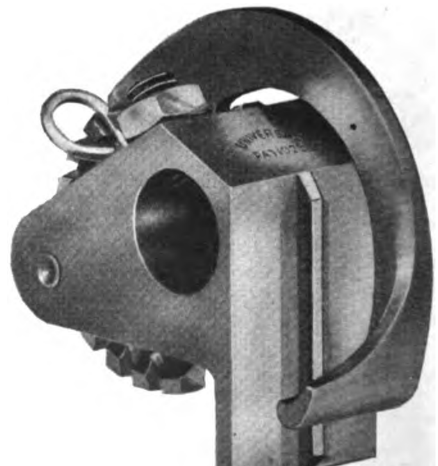
THIS "AD" IS TOO SMALL!

. . . to tell you about ALL of the GOOD POINTS of the
Universal Full-Reaction Brush Holder

. . . . Some of them are . . . .

INCREASES—Life of Brush; Life of Commutator; Commutating Efficiency.

PREVENTS—Brushes from moving sideways on commutators; Brushes from shifting or moving in holder due to side oscillation of armature; Brushes from wearing unevenly.



MARTINDALE ELECTRIC CO.
1252 W. 4th St., Cleveland, Ohio

Send me your Bulletin on Universal Brush Holders:

Name and Title ....

Company ....

Street ....

City .... State 12-27

MARTINDALE Motor Maintenance **EQUIPMENT**

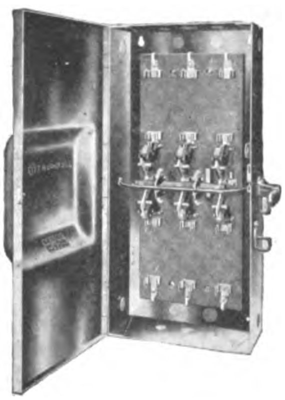
SEVERE arcing is dangerous.

It tends to impair switch jaw posts and blades; flash-overs, likewise, may result in physical injury to the operator.

The Trumbull "Snuf Arc" has two insulating barriers which confine the arc to a narrow space, preventing it from flashing over between poles or from one pole to the box. The two barriers are joined by an asbestos composition which intercepts the path of the arc between the jaw posts and the blade.

The asbestos composition in its passage over the jaw post lengthens the path through which the arc must travel and also tends to snuff the arc by cooling the copper vapor. The barriers confine the arc in such a way that it can cause no damage even under severe overload. Snuff the arc and save the switch.

"Snuf Arc" Switches



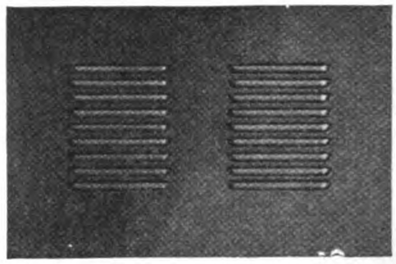
"They Break the Arc"

The switch shown at the left, is a three-pole, 600 v., A. C., 60 amp. Double Throw Safety Switch. The adaption of the "Snuf-Arc" to double throw switches is a recent accomplishment.

"Circleteed is Guaranteed"

The Trumbull Electric Mfg. Co.
Plainville, Conn.

New York Chicago San Francisco Boston Philadelphia Atlanta Ludlow, Ky.



STAMPED LOUVRES

For general purposes. Shutter operated LOUVRES for POWER HOUSES and REFINERIES

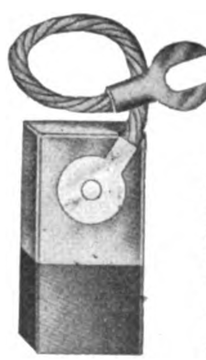
We build them to your specifications. Send pencil sketch or blue print.

THE BREESE BROS. CO., Cincinnati, Ohio

FABRICATORS OF

Steel, Iron, Brass, Copper, Monel Metal—Requiring Stamping, Forming, Drawing, Blanking, Punching

See Data A. S. M. E. Condensed Catalogue of Mechanical Equipment, McRae-Hendricks and Thomas Catalogues.



"CARENCO" BRUSHES

Mr. James Brower of the Milwaukee Sewage Disposal Plant says: "Carenco Brushes have kept the plant running without causing shut downs. The few hair I have left will now remain as my brush worries are over."

Why not let us take your brush problems and solve them?

CARBON ENGINEERING CO., Milwaukee, Wis.

Careful Laboratory Tests show:—

85% Copper Grindings
15% Resurfacer and Carbon Brush Grindings for

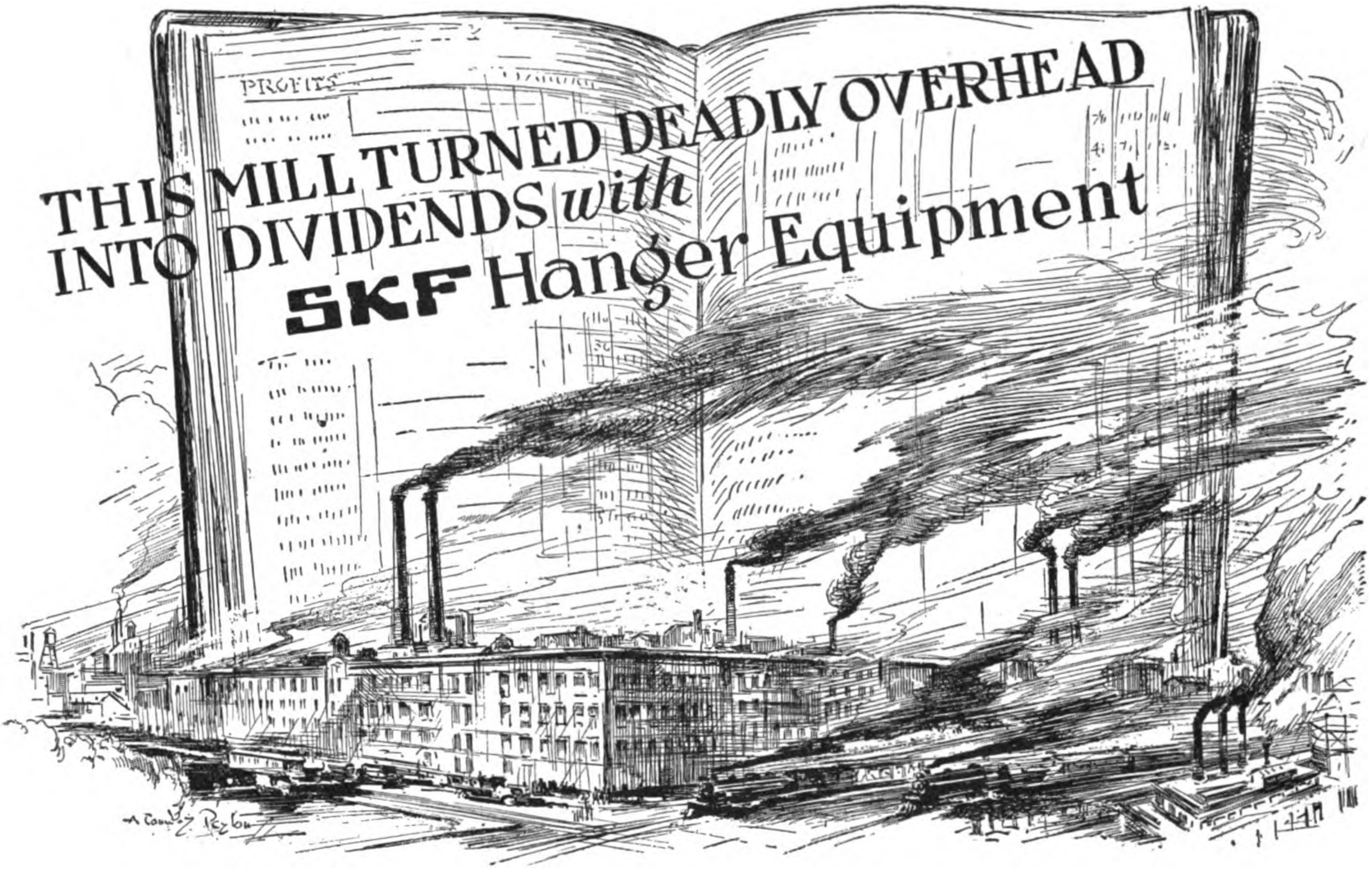
IDEAL Commutator Resurfacers

the only stones which can show this high efficiency.

Our 10 day FREE TRIAL offer will convince you.

Ideal Commutator Dresser Co., 1065 Park Ave., Sycamore, Ill.
Gentlemen: Please send me details of your free trial offer.
Name ....
Address ....
City .... State ....

THIS MILL TURNED DEADLY OVERHEAD INTO DIVIDENDS *with* SKF Hanger Equipment



YOU executives, plant engineers and all other officials interested in fighting high overhead, consider the recent experience of a large Southern textile mill.*

For years, excessive friction from troublesome plain bearing transmission equipment was increasing manufacturing costs and sending overhead skyward. Then, the decision came to install Skayef Self-Aligning Ball Bearing Hangers. As a result, a careful record of actual savings shows that the yearly power consumption was cut $1,900.00, while additional savings in maintenance and lubricant costs bring the total yearly dividend on the amount invested to 49%.

Let Skayef Ball Bearing Hangers help you fight production costs in 1928. A corps of SKF engineers is ready to offer you the benefit of their world-wide experience in friction reduction.

CHICAGO POWER SHOW FEB. 14-18

**A certified survey enumerating actual savings in this plant will be forwarded free on request. May we send you a copy?*

1927

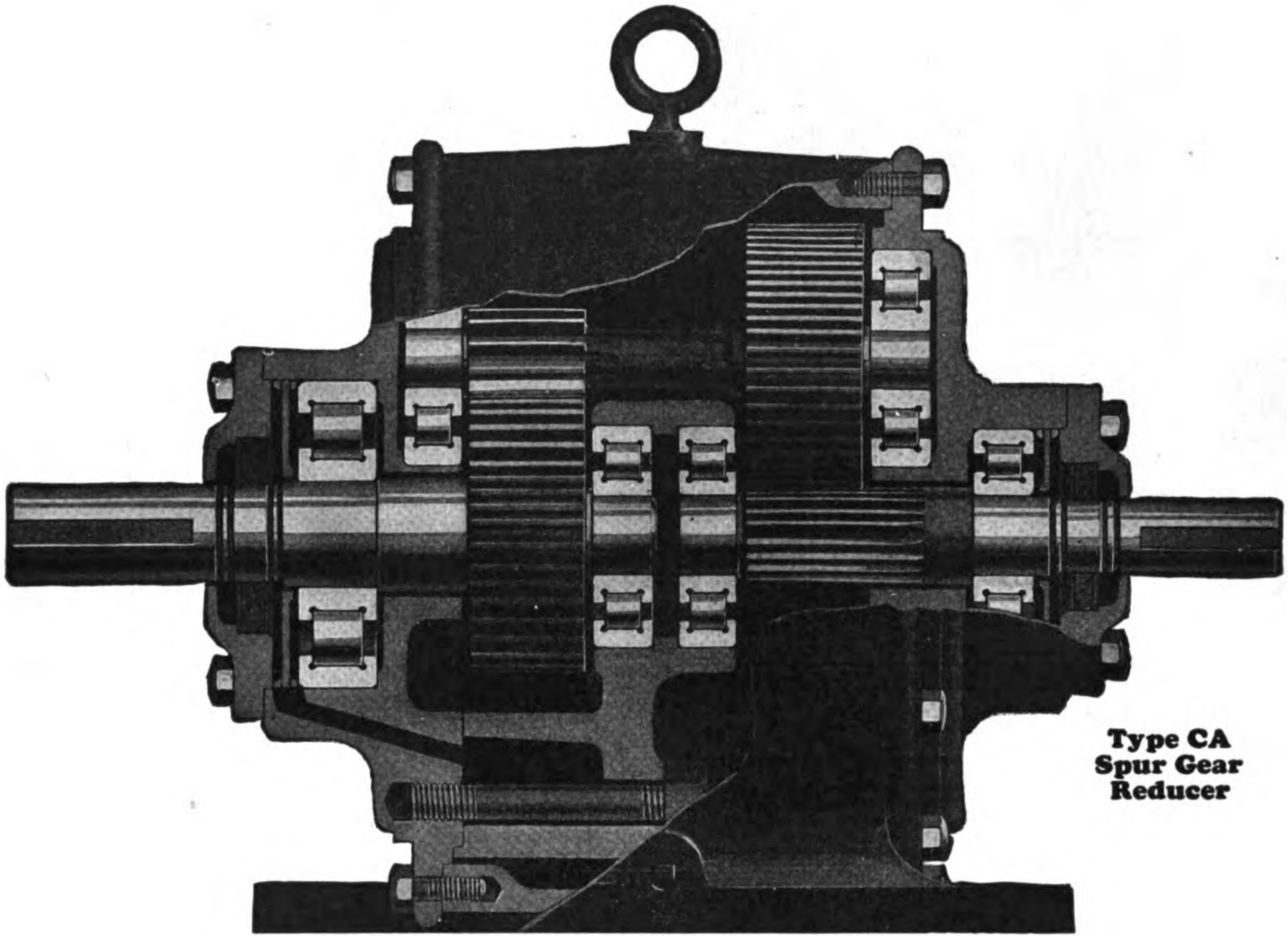
SKF

MARKED

Self-Aligning **HANGERS** *Ball Bearing*

SKF INDUSTRIES, INC. — S. E. cor. Madison Ave. at 34th St. — NEW YORK

AD SPEED REDUCERS
with Full Anti-Friction Bearings



Type CA Spur Gear Reducer

Get the Speeds You Want with Least Power Loss!

Because—1 — Full Anti-Friction Bearings
2 — Our famous "Zones of Quiet" accurately-cut Gears
3 — All shafts supported at both ends, hold gear teeth always parallel.

Also 5 other Outstanding Advantages

—The unusually compact design conserves space
—The superior rigidity of these Reducers insures least vibration
—The dust-proof and oil-proof construction insures long service
—The exceptional accessibility saves time
—Maximum possible efficiency

Write us about your Speed Reducing Problems.

AD SPEED REDUCERS
Made in Worm Gear *and* Spur Gear Types

ALBAUGH-DOVER MFG. CO., 2224 Marshall Blvd., Chicago, Ill.

We supply Gears of all kinds — Spur, Bevel, Helical, Worm, Internal, Bakelite and Raw Hide Pinion. Send us your sketches, blue prints or specifications for estimates.

This belt grips pulleys better

(*because of its soft finish*)

All Schieren Belts have a soft pliable finish that enables them to deliver full power the moment they are put on the pulleys.

If we sent belts to you with their surface jacked and rolled to a hard glaze they would require many hours of "running in." But Schieren Belts are ready to handle their full rated horse-power when they leave our hands.

Look at the surface finish on the belts you buy. Are you paying for power to break-in new belts? The soft desirable finish of the Schieren Belt is yours at no extra cost.

Duxbak Belting Trade Mark

Chas. A. Schieren Company

Tanners
Belt Manufacturers

Main Office and Factory
72 FERRY STREET NEW YORK
Branches and Distributors in All Principal Cities

A free booklet for you!

Coupon

Gentlemen:—

Please send me a copy of your free booklet

Name ....

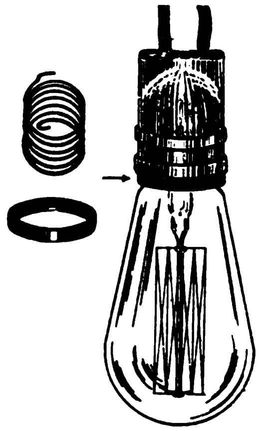
Company ....

City ....

State ....

DUXBAK
WATERPROOF
LEATHER BELTING

REN — LOCK

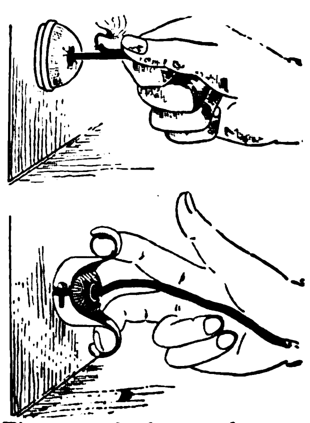


Fits standard lamps and standard brass and porcelain sockets and "Hubbell" weather-proof sockets.

Write for Free Sample and Particulars.

Sold Direct Only.

PULL A PLUG

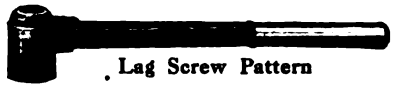


Fits standard attachment plugs.
No rewiring.
Prevents broken wires, broken plugs, and burnt-out fuses.

Order Through Your Dealer or Direct
Samples, 2 for 25 cents, postpaid

REN MFG. CO.
18 Mt. Vernon St., Winchester, Mass., U. S. A.
Cable Address: Renlock, Boston.

IT'S A
LOWELL
The General Purpose Wrench



Lag Screw Pattern

No.	Length of Handle	Average Weight	Size of Opening, Inches	
			Square	Hexagon
1	12"	2½ lbs.	⅜ taper, 1½, ⅝, [illegible], [illegible], [illegible], ⅞, [illegible], 1 $\frac{1}{16}$, 1 $\frac{1}{16}$, 1¼	[illegible], [illegible], ⅞, [illegible], 1 $\frac{1}{16}$, 1¼.
2	16"	4½ lbs.	1, 1 $\frac{1}{16}$, 1¼, 1 $\frac{1}{16}$, 1⅝, 1 [illegible]	1 $\frac{1}{16}$, 1¼, 1 $\frac{1}{16}$, 1⅝
3	20"	10 lbs.	1, 1 $\frac{1}{16}$, 1 $\frac{1}{16}$, 1¼, 1 $\frac{1}{16}$	1, 1 $\frac{1}{16}$, 1¼, 1 $\frac{1}{16}$, 1⅝, [illegible]

Don't let your workmen waste their time with the ordinary wrench.

Give them a REVERSIBLE RATCHET WRENCH with the name LOWELL on it.

It pays now. It will pay in the end.

A Ratchet Wrench for Every Purpose.

LOWELL WRENCH CO.
54 Commercial St., WORCESTER, MASS.
Ask your Hardware Dealer for them or send for Catalogue.

What the Chicago Power Show means to YOU

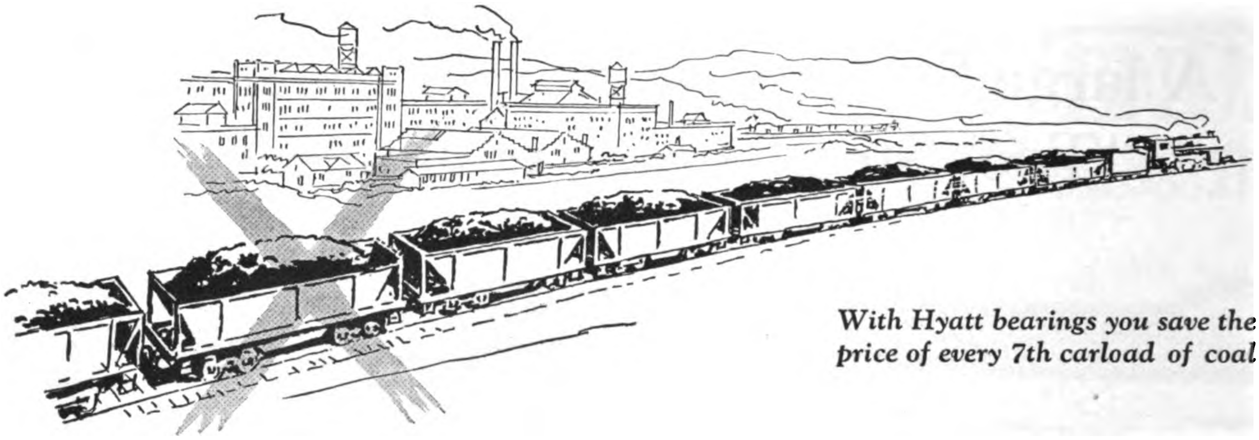
1. An opportunity to see the latest and most modern power equipment of the foremost manufacturers.
2. A broadening of your education by means of actual comparison.
3. A place to discuss your problems with several recognized experts.
4. A place to study modern methods and processes in power plant operation.
5. An opportunity to investigate low operation costs and standard practice.
6. A place of education for greater usefulness and earning power in your profession.
7. An opportunity to renew old friendships and make new ones.
8. A place to buy for your future needs.

MIDWESTERN ENGINEERING EXPOSITION, Inc.
53 W. Jackson Blvd., CHICAGO, ILL.

Meet with the Masters of Power at the

Chicago Power Show

Coliseum February 14th to 18th



Let proved power saving govern your choice of bearings

Although there are other advantages to be considered in the selection of line shaft bearings, in the final analysis power saving should be the deciding factor.

An assured 15% saving on your total power bill—and in many cases more—makes Hyatt Line Shaft Roller Bearings an economic necessity in your plant.

A typical example of Hyatt power saving is found in these figures.

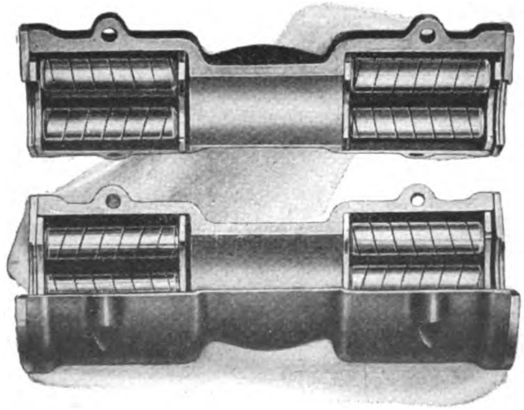
A plant appropriated $10,000 to replace babbited line shaft boxes with Hyatt Roller Bearings.

They saved $5,400 the first year on power (15% on 900 H.P. at $40 per H.P.); $750 on maintenance (75% of $1,000); $240 on lubrication (80% of $300). This total of $6,390 represents a return of 63.9% on the initial investment. In another seven months the bearings paid for themselves.

Whether your plant is large or small—Hyatt Roller Bearings will prove a paying investment.

HYATT ROLLER BEARING COMPANY

Newark Detroit Pittsburgh Chicago Oakland

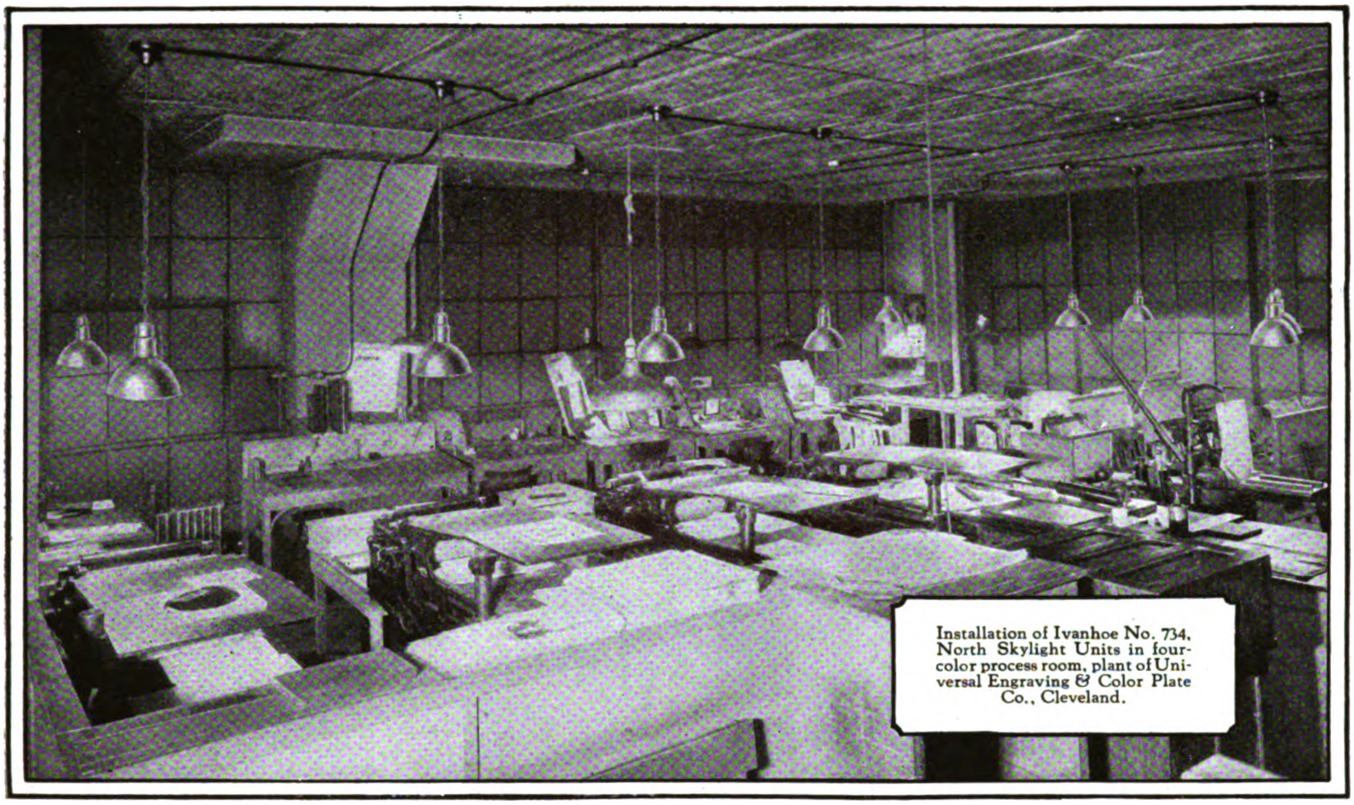


Completely split for quick, easy installation

HYATT

ROLLER BEARINGS

PRODUCT OF GENERAL MOTORS



Installation of Ivanhoe No. 734, North Skylight Units in four-color process room, plant of Universal Engraving & Color Plate Co., Cleveland.

Ivanhoe Trutint Units Help Artists Match Colors for Universal Engravers

Ivanhoe RLM standard dome reflector. Distributes light scientifically. Also standard bowl and angle reflectors.

Ivanhoe Glassteel Diffuser Produces diffused illumination of highest quality. Latest development for industrial lighting.

Ivanhoe vapor-proof unit. For use where protection from dust or fumes is required.

In the manufacture of four-color process plates, colors must be matched *accurately!* That is why Universal Engraving and Color Plate selected Ivanhoe Trutint Units for lighting their four-color process shop.

Ivanhoe Trutint Units are made for industries where it is desirable that artificial illumination blend with daylight, or where accurate discrimination of colors and tints is essential. The textile, food, printing, tobacco, dye and paint industries, for instance. Units to provide a true north skylight or a noon sunlight are available.

The complete Ivanhoe line includes standard equipment for the regular lighting job, and special equipment for the unusual and often difficult job. All, plus a helpful engineering service. Write for catalog.

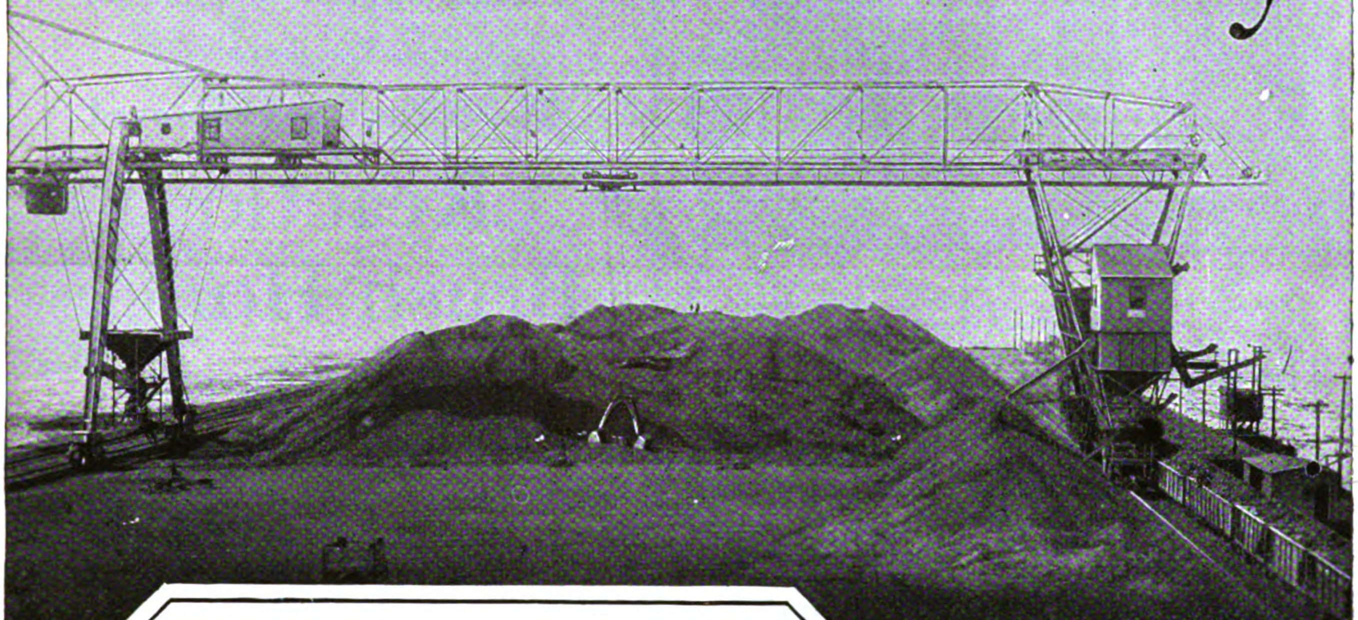
IVANHOE DIVISION
of THE MILLER COMPANY
Cleveland, Ohio

Ivanhoe industrial flood lighting unit. Makes light penetrate smoke or steam. May be mounted high.

Ivanhoe dust-cover unit. Protects surface of the reflector from deterioration from smoke, steam, etc.

Ivanhoe Trutint unit. For use where artificial light must blend with daylight, for color matching, etc.

Service no weather can delay



THREE weeks to the close of Great Lakes navigation in Wisconsin—the winter's coal supply yet to be unloaded from the barges by the Company's coal tower—ice already forming.

And then—the main hoist motor went out of service.

In response to a long distance call for help, two G-E Service Shop men were on their way that night. Rewinding of both stator and rotor was required. The rotor was sent back to the Service Shop for repairs, while the men worked at the top of the tower for five days rewinding the stator, unprotected from the rapidly dropping temperature. Eleven days after the emergency arose, the coal was again being hoisted.

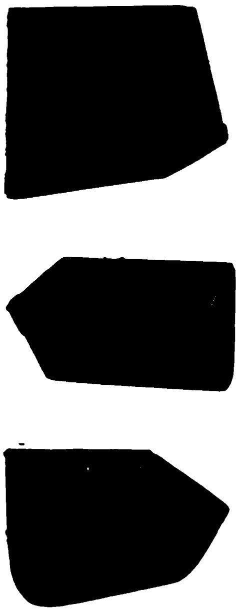
Such is the G-E standard of service. It pays to feel that men who know how will take care of you in an emergency. There are G-E Service Shops in 21 cities. There is one near you.

You are never out of reach of G-E Service. Express will reach the nearest Service Shop overnight. If the job is too large to ship, experienced men will come to you. Our shops are located in the following cities:

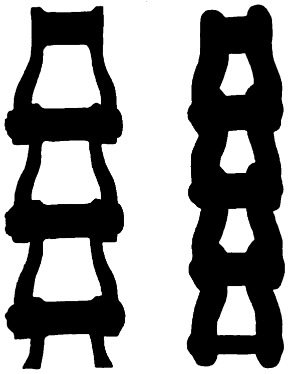
Atlanta	Erie	Oakland
Buffalo	Fort Wayne	Philadelphia
Chicago	Kansas City	Pittsfield
Cincinnati	Los Angeles	St. Louis
Cleveland	Lynn	Salt Lake City
Dallas	Minneapolis	Schenectady
Detroit	New York	Seattle

GENERAL ELECTRIC

- Belt Conveyors
- Bucket Elevators
- Screw Conveyors
- Weigh Larries
- Coal Crushers
- Ash Skip Hoists
- Flight Conveyors
- Track Hoppers and Feeders
- Pivoted Bucket Carriers
- Lehr Conveyors
- Coal Bunkers and Gates
- Power Transmission Machinery
- Barrel and Box Elevators
- Elevator Buckets
- Car Pullers
- Bag Elevators
- Steel Chains
- Malleable Iron Chains
- Sprockets



Get our prices on the items you are interested in!



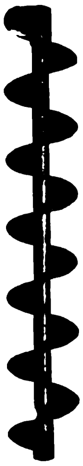
Webster installations —throughout industry

"Lower production costs" is a slogan in American industry which Webster equipment is helping to make a reality.

In the modern trend toward the use of labor-saving equipment WEBSTER installations are specially built for mechanical production and the saving of man power.

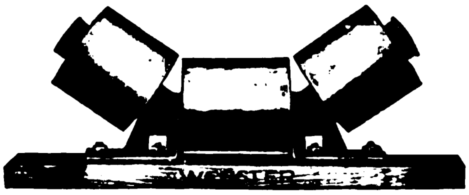
Webster engineers are constantly studying the problem of production costs. Every Webster installation is planned with this element in view—to give dependable, day-in-and-day-out service and the delivering of the finished product at the very minimum cost figure.

Webster elevating and conveying systems; screening equipment; coal and ashes handling machinery; bucket elevators; belt conveyors; screw conveyors; feeders; weigh larries; pivoted bucket carriers—*these are a few items from the complete Webster line.*



THE WEBSTER MANUFACTURING CO.

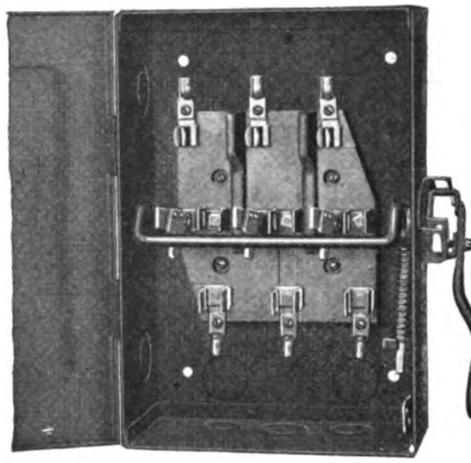
1856 No. Kostner Avenue,
Chicago, Illinois



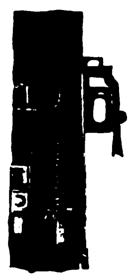
New York	*Philadelphia*	*Pittsburgh*
Cincinnati	*Cleveland*	*Buffalo*

—Write to— WEBSTER

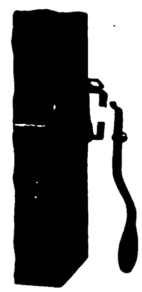
Type "C" A Good All-Round Safety Switch



Type "C" Safety Switch



Quick Make and Break



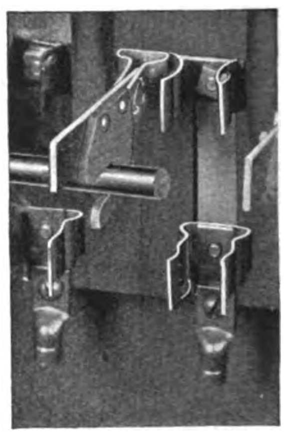
Removable Handle

The Type "C" Safety Switch is built for light industrial loads although it is adaptable to many uses outside the industrial field. It is a good all around safety switch. Several new features have been added and we call your particular attention to them here.

1. Quick Make and Break mechanism.
2. Removable Handle, saves breakage in shipping.
3. An insulated blade construction which allows fuses to be taken out easily. Reduces size of panel.
4. Ample wiring space.

These switches supplement our line of higher priced Type "A" Switches for mill purposes. Our concentric knockouts leave the hole clean as a hound's tooth.

Do you want more information about these Type "C" Safety Switches? Just drop us a line.



Blade Construction

TRUMBULL-VANDERPOEL ELECTRIC MFG. CO.
BANTAM, CONN.

NEW YORK BOSTON CLEVELAND CHICAGO DETROIT PHILADELPHIA

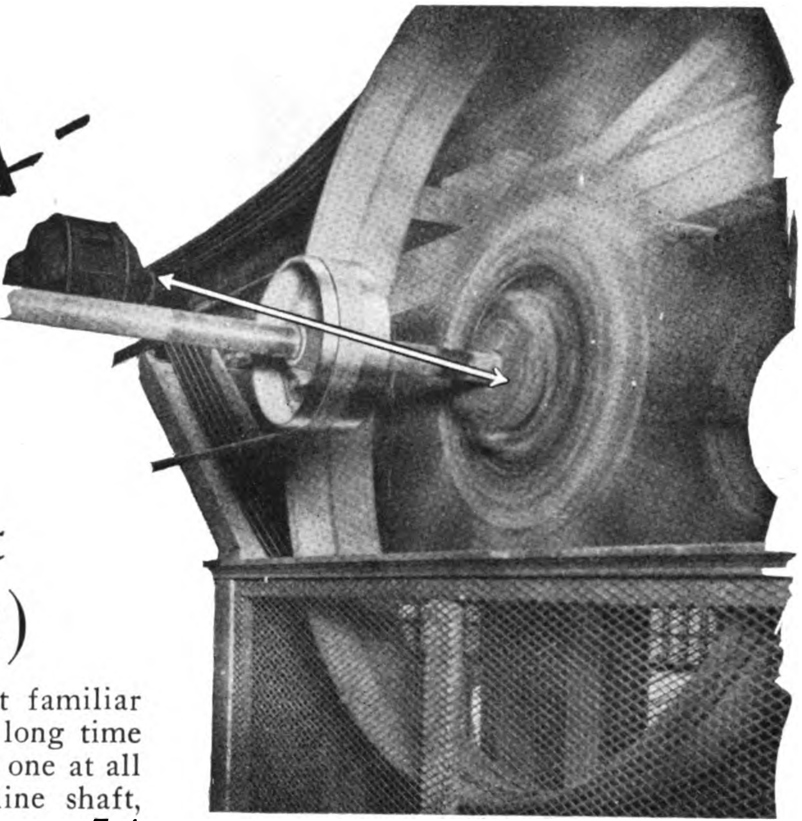
On the Pacific Coast—C. Dent Slaughter

TV SAFETY SWITCHES

TENTACULAR

"The Belt with the grip of an Octopus"

Ideal for short centers—



(—and here's what we mean by short)

Almost any engineer who was not familiar with Tentacular would hesitate a long time before considering a drive like this one at all possible. And yet, here is this line shaft, heavily loaded, taking its power from a 7¼ inch pulley. The shaft pulley is 7½ *feet* in diameter and the center to center distance is only 9 feet. In spite of this enormous ratio and close separation, the top of the belt is slack, and there is no measurable slippage. Why?

Because Tentacular clings to the pulley surfaces. Its under surface is soft chrome tanned leather, fastened by hollow rivets to a sturdy, seasoned, oak leather base. The suction created when the belt is in motion prevents the slip common to any belt on drives of high pulley ratio.

Idlers are unnecessary. Low belt tension is the rule. Slippage is practically eliminated. Pulley faces need no grooving nor change. And the Tentacular belt lasts for years and years.

TENTACULAR

will positively increase speed and machine production by cutting down belt slip—will lower power costs by lowering belt tensions and friction loss.

Tentacular will eliminate the idler in a majority of drives. Tentacular should be used wherever belt tensions are high.

Tentacular should be used wherever pulley ratios are high and short centers are unavoidable.

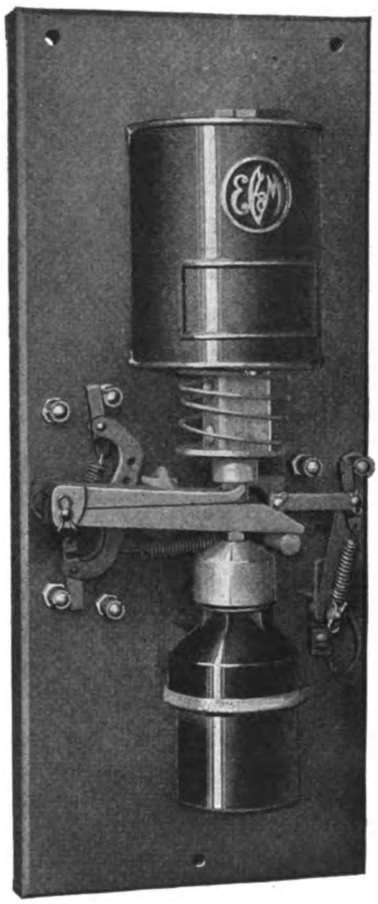
Let us talk it over with you.

CHICAGO POWER SHOW FEB. 14-18

Alexander Brothers, (INC.)

14 SOUTH STREET, PHILADELPHIA, PA.

An Accurate Time Delay Relay



This new relay operates to open a circuit or to close a circuit after a predetermined time interval, which may be as long as two minutes. The timing is adjustable for any period throughout the operating range of the relay.

The time delay is secured by the escapement of mercury through an orifice and is very accurate. No dash pots are used, no pendulums, no clock work. Temperature changes do not affect the operation or accuracy.

Type HG Relays are made for operation on alternating or direct current circuits.

Type HG Relays have many applications. They are used with synchronous motor starters for controlling the D.C. field contactor. They are used with automatic skip hoist controllers for holding the skip stationary in the dumping position for several seconds to permit it to discharge its load; for introducing a delay in the sequencial starting or stopping of an interlocked conveyor system; and, in fact, for any service requiring an accurate and dependable time delay relay.

THE ELECTRIC CONTROLLER & MFG. CO.

CLEVELAND, OHIO

NEW YORK-50 CHURCH ST.
CHICAGO-CONWAY BLDG.
DETROIT-DIME BANK BLDG.
BIRMINGHAM-BROWN-MARX BLDG.
CINCINNATI-1st NATIONAL BANK BLDG.
LOS ANGELES-912 E. THIRD ST.
SALT LAKE CITY-228 SO. W. TEMPLE
TORONTO-REFORD BLDG.
PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
MONTREAL-DRUMMOND BLDG.
TULSA-217 E. ARCHER ST.

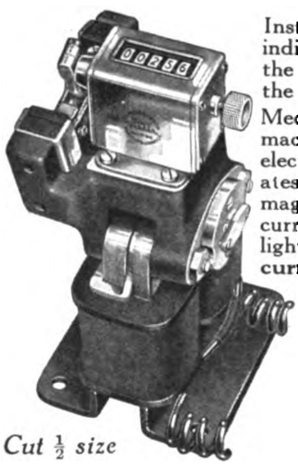
To Call a Halt On Spendthrift "Automatics"

The operating and maintenance cost of an automatic machine may be three times as great as the expense of a simple machine. When the "automatic" isn't running full time, it's running away with your money—fast.

There's now a Counter to tell—in your office—when a machine in the shop isn't running, or producing enough. It's the new *Alternating Current MAGNETIC*

Veeder

This "Form US" Magnetic Counter counts operations or units of output, from any distance that wires connect with machines.



Cut ½ size

Installed in your office, it indicates work being done by the man and machine out in the factory.

Mechanical contacts on your machine make and break the electrical circuit which operates the counter. The electromagnetic drive can get its current from your regular lighting circuit, alternating current, either 55, 110 or 220 volts, as ordered. For operation by direct current or storage battery, specify "Form UM" Magnetic Counter. For alternating current, "Form US."

The *Set-Back Rotary Ratchet Counter* below counts one for each oscillation of the lever, as required in counting the product of presses.

Goes directly on machine; non-magnetic. Sets back to zero from any figure by turning knob once round. Supplied with from four to ten figure-wheels, as needed. Price with 4 figures as illustrated, $11.50 (subject to discount). Equipped with lock and keys to prevent tampering with the record, $2 extra. (Cut ½ size.) Set-Back *Revolution* Counter of similar model, price $10.00 (list).

Write for the full-line Veeder booklet of mechanical and magnetic counters.

The Veeder Mfg. Co.

31 Sargeant Street, Hartford, Conn.

Slack Belts Prevent 3 Costly Belt Evils

Depending of course upon the number of belts used in a plant, savings of many dollars a year are being regularly made by running belts slack (instead of tight), after treatment with Cling-Surface. Slippage is reduced to natural creep, bearing troubles from strain of tight belts eliminated, and the life of belts greatly prolonged because of new flexibility and preservation.

A special survey by engineers in a New England mill (name on request), where over 500 belts had been treated with Cling-Surface, uncovered an average saving of $25.70 per year per belt—this does not take into consideration power savings, which could not be accurately checked.

Prove Cling-Surface benefits and economies to your own satisfaction with a 60-day approval test—or do not pay us one cent. Let us send trial quantity at $3.50 per one gal. size; 3 gals. at $3.40 per gal.; 6 gals. at $3.25 per gal. State whether conditions are warm, dry, dusty, or reverse. Cling-Surface Co., 1020 Niagara St., Buffalo, N. Y.

Openings for good salesmen

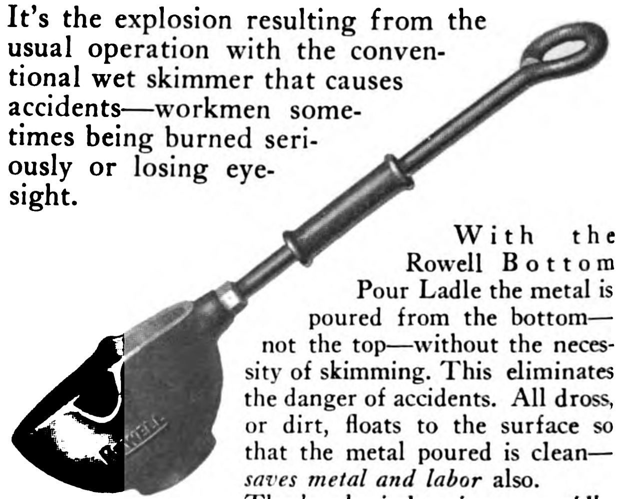
Cling~Surface

SCIENTIFIC BELT TREATMENT

KNOWN FOR 30 YEARS

Protect Your Workmen Against Accidents when Pouring Metals

It's the explosion resulting from the usual operation with the conventional wet skimmer that causes accidents—workmen sometimes being burned seriously or losing eyesight.



With the Rowell Bottom Pour Ladle the metal is poured from the bottom—not the top—without the necessity of skimming. This eliminates the danger of accidents. All dross, or dirt, floats to the surface so that the metal poured is clean—*saves metal and labor* also.

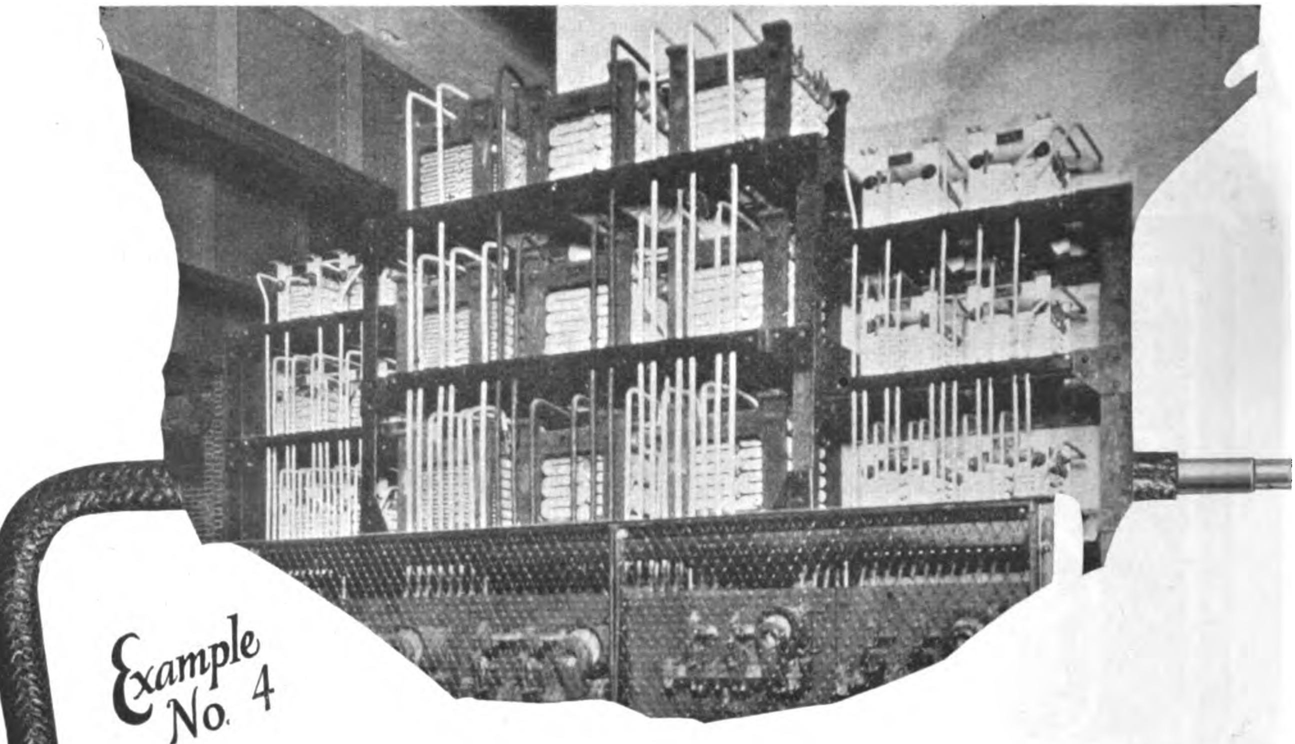
That's why industries are rapidly adopting the Rowell Bottom Pour Ladles. Let us tell you more about this ladle.

ROWELL MFG. CO., Appleton, Wisconsin

ROWELL

Listed as Standard by Underwriters Laboratories.

WHY WHEN and WHERE TO USE ROCKBESTOS —the asbestos covered wire



Rockbestos has been developed for the electrical industry's use on furnaces, ovens, switchboards, controllers, boiler room lighting circuits, motor leads and internal connections and other equipment requiring wire immune to heat.

Here is a typical opportunity for ROCKBESTOS

Conditions existing in proximity to this resistor bank of a starting panel vividly illustrate the reason for using Rockbestos —the asbestos covered wire—for any condition where high temperature might damage equipment or interrupt operations.

Frequent starting of motors generates heat. Motor starting resistors are maintained at high temperature—frequently becoming red hot. Rockbestos insulation is built to withstand these extreme conditions. It will not disintegrate or deteriorate even after long use.

Our engineers will gladly co-operate with you on any special application.

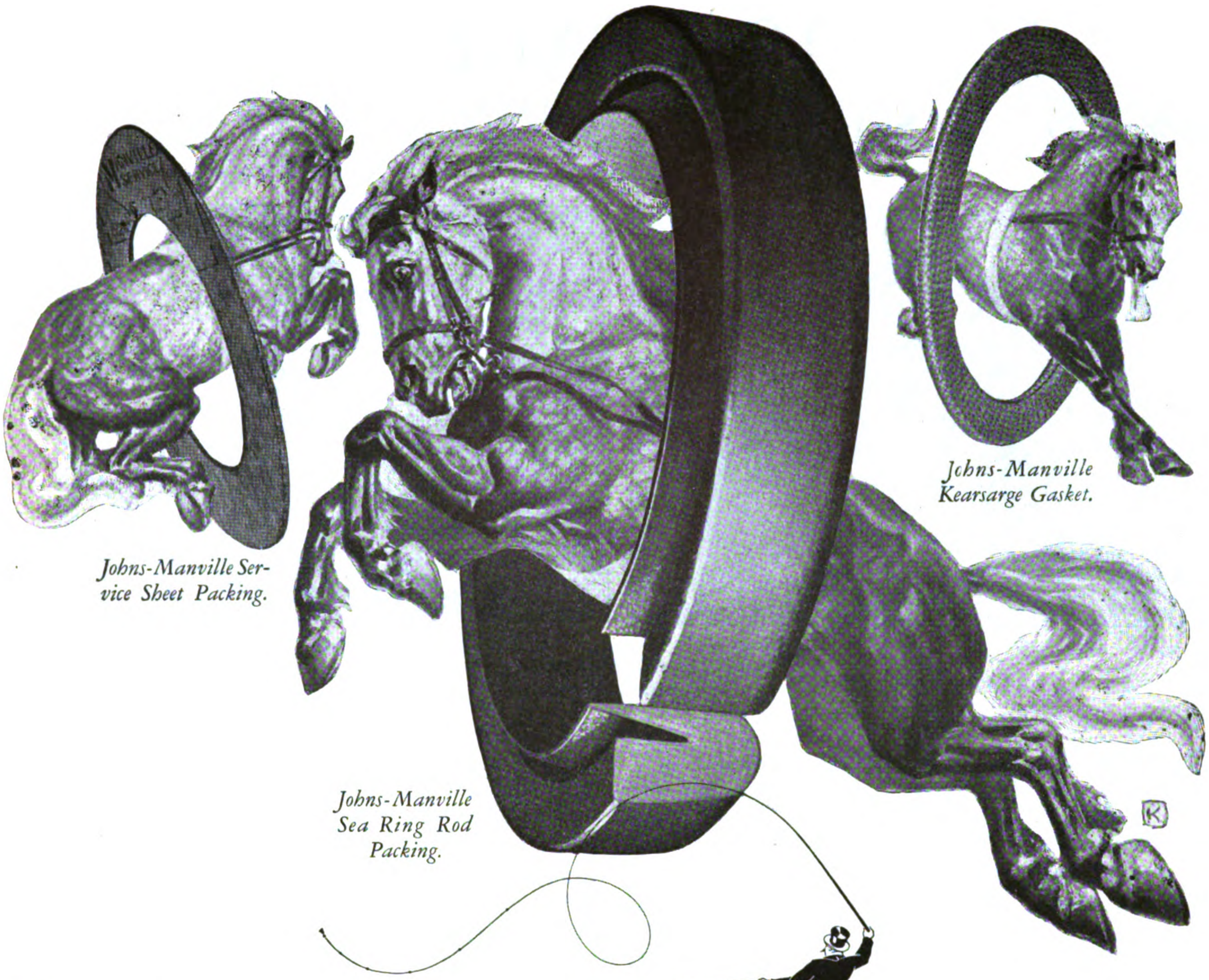
Our new Bulletin on Rockbestos Wires and Cables sent on request.

ROCKBESTOS PRODUCTS CORPORATION

NEW HAVEN, CONN.

5942 Grand Central Term. Bldg., New York, 465 Union Trust Bldg., Pittsburgh, Pa., 224 Madison Term. Bldg., Chicago

On the Pacific Coast—Allied Industries, Inc.



Perform, horsepower *perform-*

Queer looking hoops, aren't they? Yet they are directly responsible for the fine performance of horsepower in many an industrial plant. They are Johns-Manville Packings.

As the washer in your kitchen faucet prevents water leakage, so do these packings prevent steam leakage in power plants . . . and save horsepower.

They are only a few of the highly efficient group of packings, insulations and refractories, based on Johns-Manville Asbestos and allied materials.

These products and the Johns-Manville men who sell them, power specialists they are, constitute a Johns-Manville Service to Industry of great value in the industrial field.

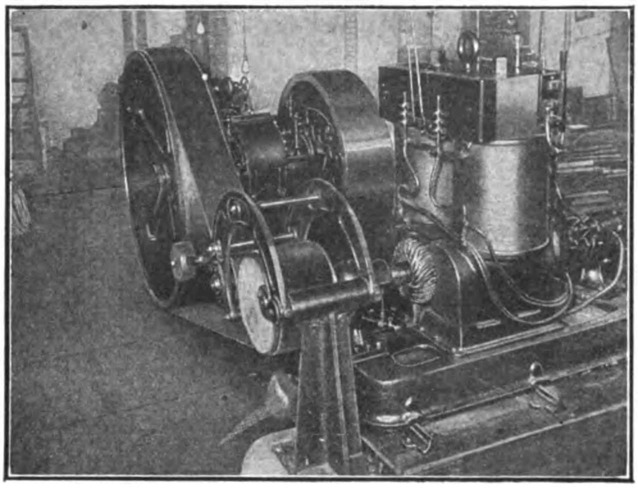
Shrewd plant engineers know this and regularly call upon Johns-Manville . . . men and materials . . . to reduce operating costs by getting finer performances from horsepower.

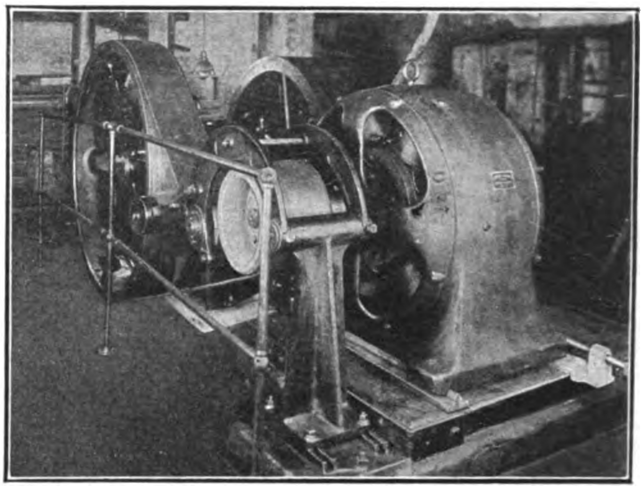
ASBESTOS SAVES HORSEPOWER

JOHNS-MANVILLE
SAVES HORSEPOWER

JOHNS-MANVILLE CORP., MADISON AVE. AT 41ST ST., NEW YORK. BRANCHES IN ALL LARGE CITIES. FOR CANADA: CANADIAN JOHNS-MANVILLE CO., LTD., TORONTO

19 YEARS' STEADY SERVICE





65 H.P. Steam Engine Driven Generator.
Pulley Centers 6-ft. 6-in.

THE original open drive connecting a 65 H.P. steam engine and a bi-polar generator on 16-ft. 0-in. centers gave continuous trouble because of excessive belt slippage.

In 1908, a LENIX was installed, as illustrated above at the left. The LENIX eliminated all actual belt slippage, gave efficient transmission of the power and in general, improved the operating conditions. Incidentally, the LENIX permitted the installation of these units on 6-ft. 6-in. centers, saving about ten feet of valuable floor space.

For *seventeen years,* this installation was in daily service and, with the exception of one new belt, the outlay for upkeep was in the words of the superintendent, "not a cent."

In 1925 the old steam engine and generator were replaced by modern units, and as illustrated above at the right, the old LENIX was used with the new equipment.

This record of over ***nineteen years*** of daily service is proof of the reliability and soundness of design and construction of the LENIX. This installation is only one of many still in service after nearly twenty years of operation. There are now thousands of LENIXES installed on drives in units of from 1 H.P. to 1400 H.P. in practically every industry.

The LENIX is the pioneer short center belt drive. Our extensive experience, the result of more than twenty years of designing and building LENIXES, is offered for the solution of your belt drive problems.

A card will bring you full information.

The LENIX Saves

Power
Building Space
Belting
Bearing Friction
Lubrication
Maintenance Cost
First Cost of Motors, Generators, etc.
On drives 1-1400 H.P., and up.

The LENIX *Drive*

(Trademark Registered)

F. L. SMIDTH & CO.

Engineers

40 Church Street, New York, N. Y.

The doctor takes his own medicine!

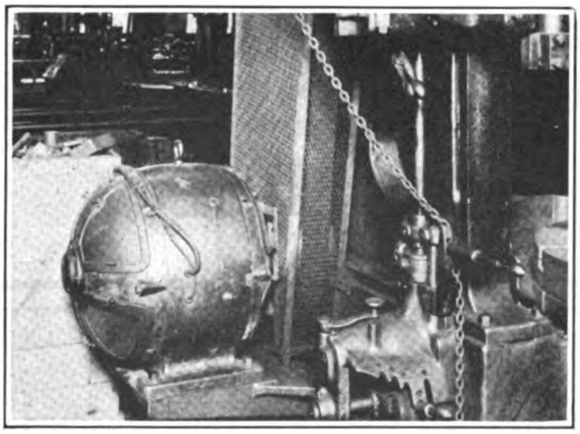
We have our problems of cost and production just the same as any other manufacturer. And our Works Manager, when he needs motors, is far more interested in performance than name plates.

The motors in our plants are Electro-Dynamic motors simply because they give us the kind of service that enables us to produce their mates most efficiently. One of our production motors, for instance, has been driving a boring mill in our machine department for the past 20 years and is still in daily operation. This, as you know, is a mighty tough job, and the motor, naturally, of an old type. Yet we give you our word, as progressive manufacturers, that maintenance is, and always has been, extremely low. Never once has this motor caused us loss by breaking down.

Maybe you, too, have been looking for just this kind of motor service. If so, we will gladly give you further details and plenty of operating data.

Write us.

ED
The Pioneer Manufacturer of Ball Bearing Motors



The Interpole Direct Current Motor

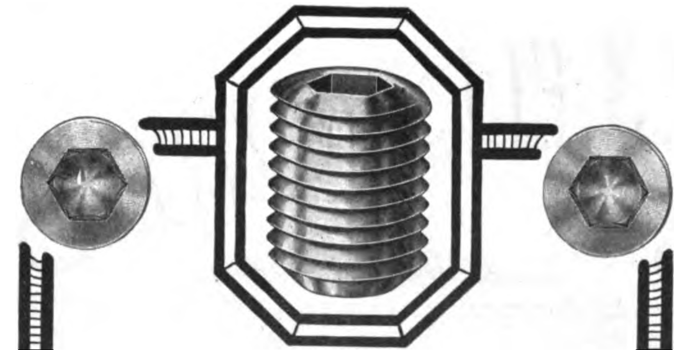
Electro Dynamic engineers were first to build a successful INTERPOLE D.C. motor. Since that time the design has been widely imitated and has found application in every branch of industry, particularly on machine tools.

High efficiency, utmost simplicity, and accurate control of speed make E.D. Ball Bearing D.C. Interpole Motors by far the most satisfactory installation for machine tool operation. Many of our earlier units are still operating after years of everyday service. Bulletins of both D.C. and A.C. equipment for every industrial purpose on request.

Electro Dynamic Company, Bayonne, N. J.

Established 1880

Manufacturers of Direct and Alternating Current Motors



For One Cent

It is not the cost of set screws, but the enormous cost of set screw *breakage* which makes careful buying imperative.

There is less than one cent's difference in price between the strongest and weakest hollow screw:—between a cold-drawn ALLEN and an ordinary broached screw.

But for that same broached screw *broken down*, add the cost of mechanic's time digging out the screw. Add the cost, perhaps, of dismantling a machine. Add your loss in production.

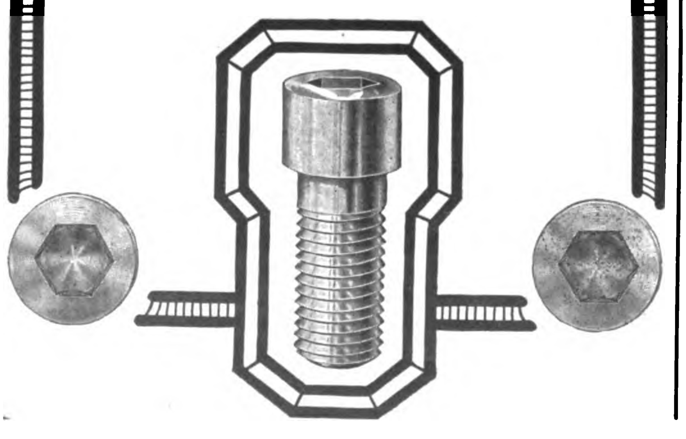
Would you risk these things—for *one cent?*

The Allen Mfg. Co.

127 Sheldon St., Hartford, Conn.

Branch Offices:

W. C. Stauble 2909 *Waverly St.* *Detroit, Mich.*	*R. E. Gregory* 1029 *Wesley Ave.* *Evanston, Ill.*
E. P. Crawford 3348 *No. Park Ave.* *Philadelphia, Pa.*	*W. J. McRae* 320 *Market St.* *San Francisco, Cal.*

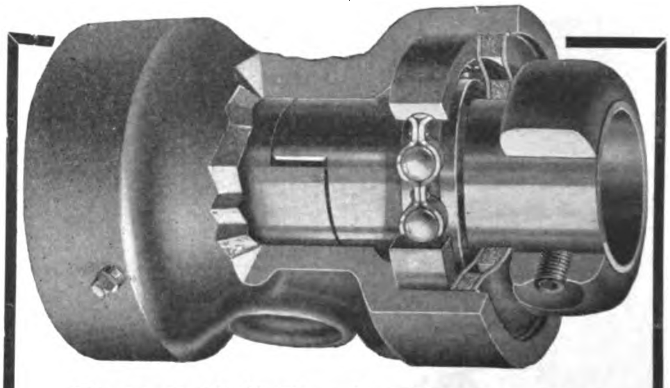


Your Plant

Can Avoid Breakdowns If You Install

"CHICAGO LINE"

Ball Bearing Appliances



Daggett Ball Bearing Hanger Box

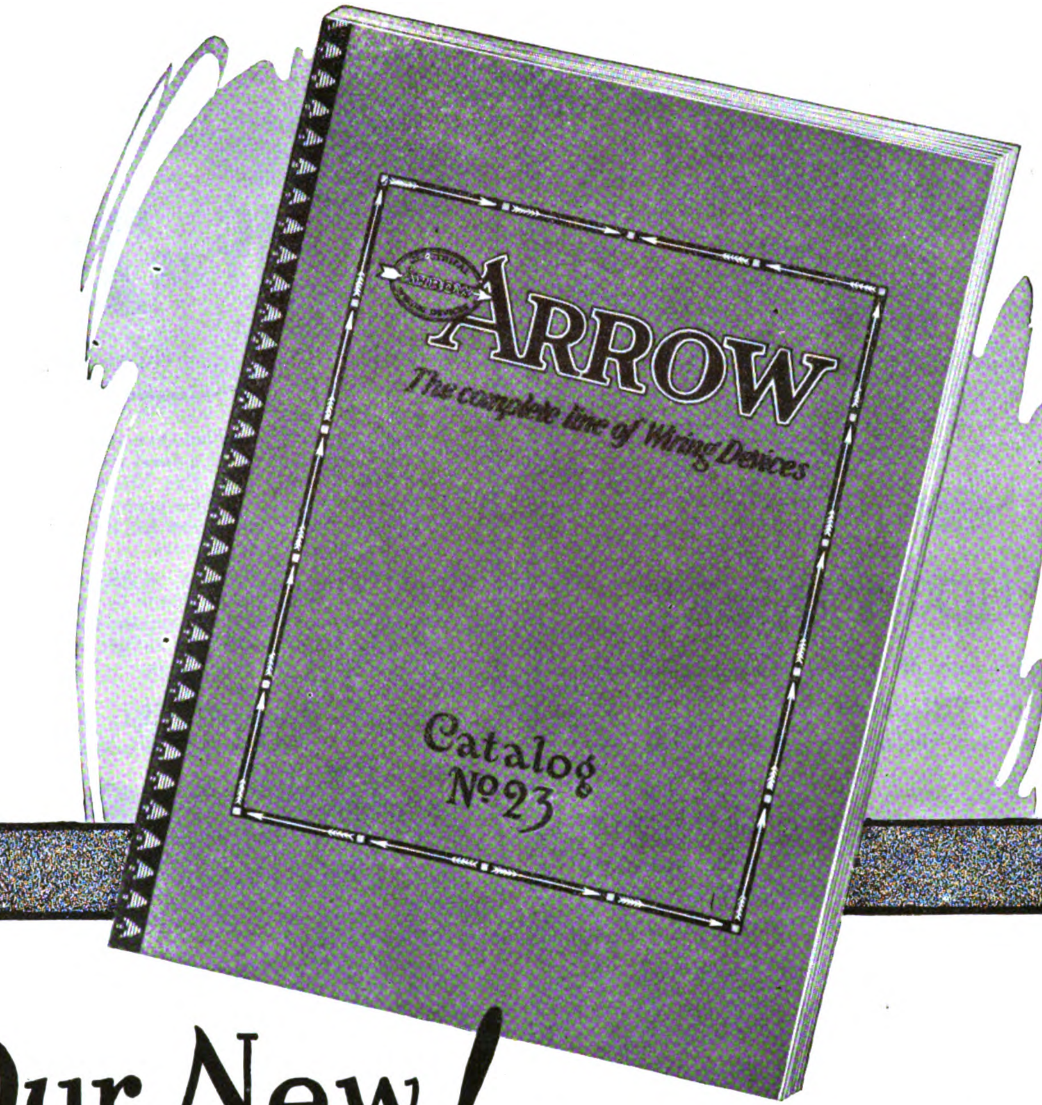
TODAY, the demands for increased production and economy often necessitate a continuous running plant. Shut-downs, caused so often by burnt out bearings where old style equipment is used, are costly in the extreme.

"Chicago Line" Ball Bearing Equipment now has made this waste unnecessary. If you install "Chicago Line" Equipment, friction need never bother you again.

The Daggett Ball Bearing Hanger Box is simply constructed, easy to install and fits any standard hanger frame. It is noiseless, dustproof, will operate at any speed without heating and cannot wear the shaft. Just oil it a few times a year and forget it the rest of the time.

Let our transmission engineers tell you how to reduce your Fire Hazard!

CHICAGO PULLEY & SHAFTING CO.
21 NORTH DESPLAINES STREET
CHICAGO, ILLINOIS



Our New! Catalog

The Arrow Electric Company is now ready to place at your disposal their new Catalog No. 23 listing a complete line of Industrial Wiring Devices.

New devices are shown and new lines have been added. Send for your copy.

The Complete Line of Wiring Devices

THE ARROW ELECTRIC CO.

HARTFORD, CONNECTICUT

Please send me a copy of the ARROW CATALOG No. 23.

Name..

Address..

....

IE-12-27

CHOTA HAZRI

The Kaffir's test of character, stamina and integrity is the meal (chota hazri).

The fellow with the biggest appetite gets the important post.

Thus a man's job is reached through his stomach.

And we've noticed that sometimes the operators of electric machines try to qualify in similar manner.

They equip their machines with a heterogeneous medley of nondescript carbon brushes and after they've had a belly full of the troubles that such a conglomeration superinduces they feel that they've qualified for an important change.

And THEY *have!!*

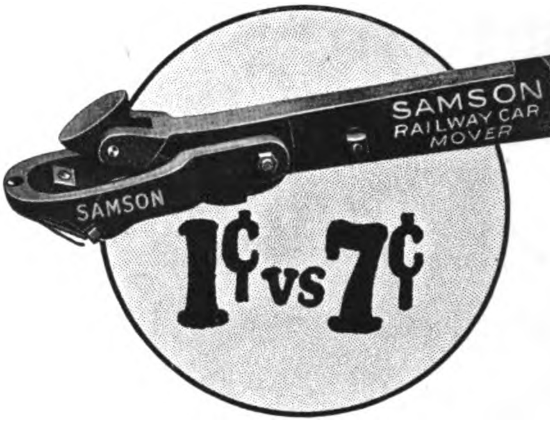
They've qualified for an engineering prescription of Morganite Brushes.

Morganite Brush Co., Inc.

Main Office and Factory
3302-3320 Anable Ave., Long Island City, N. Y.

DISTRICT ENGINEERS AND AGENTS

Pittsburgh, Electrical Engineering & Mfg. Co., 909 Penn Ave.
Cincinnati, Electrical Engineering & Mfg. Co., 607 Mercantile Library Building.
Cleveland, Electrical Engineering & Mfg. Co., 422 Union Building.
Baltimore, O. T. Hall, Sales Engineer, 437-A Equitable Building.
Revere, Mass., J. F. Drummey, 75 Pleasant Street.
Los Angeles, Electrical Engineering Sales Co., 502 Delta Building.
San Francisco, Electrical Engineering Sales Co., 222 Underwood Building. 545 Market Street.
Toronto, Can., Railway & Power Engineering Corp., Ltd., 101 Eastern Ave.
Montreal, Can., Railway & Power Engineering Corp., Ltd., 68-70 St. Antoine St.
Winnipeg, Can., Railway & Power Engineering Corp., Ltd., P. O. Box 325.



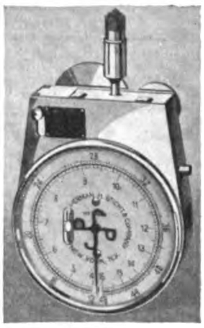
That's the difference between moving a car loaded with 50,000 pounds on a level track one foot with a Samson Rail Gripper Car Mover and moving the same car one foot with a crew of men and a crow bar—the important reason for the present wide use of the Samson Car Movers.

The Samson Rail Gripper is backed by thirty years of service to industry. Made by the first and oldest manufacturers of wood handle car movers in the world. It will pay you to get a Samson today. *Your dealer can supply you.*

G. D. ROWELL & SON
Appleton, Wisconsin

Samson
RAIL GRIPPER

POCKET SIZE TACHOMETER



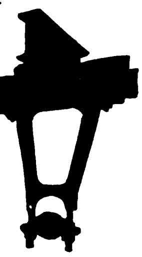
SPECIAL FEATURES

Size: $\frac{11}{16}$ inch high and $3\frac{5}{16}$ inches long.
Weight: 10 ounces.
Finish: Nickel plated steel.
Accessories: Duplex rubber and steel point and two discs.
Spirit Level: To facilitate holding instrument in horizontal position.
Pointer Locking Device: Not found on any other tachometers.

Bulletin No. 221 mailed on request.

HERMAN H. STICHT & COMPANY
21 Park Row New York, N. Y.

Complete flexibility



that readily permits rearrangement of tools, etc. without the usual labor costs and inconvenience.

Write for details.

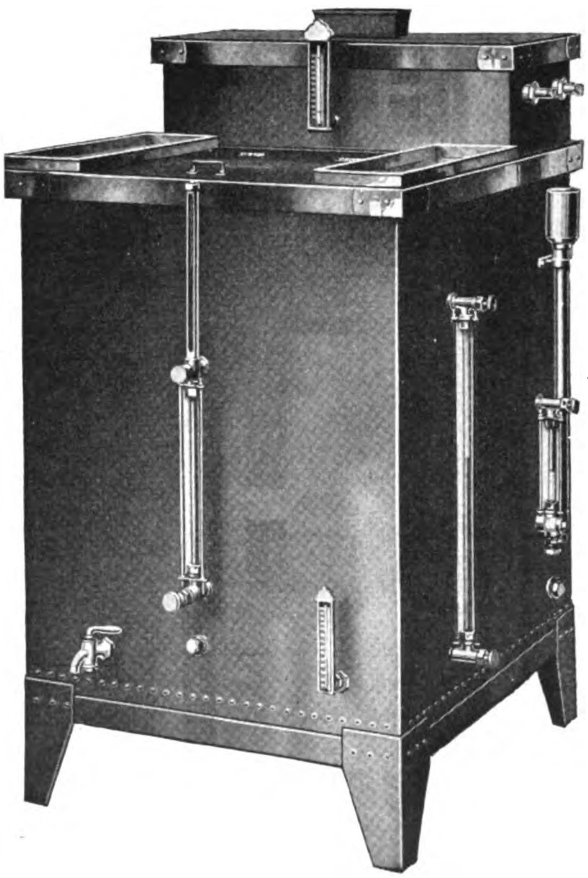
Midwest Steel & Supply Co.
Bradford, Pa.

Oil 17 years old —here is how it analyzed

Oil used for 17 years, with annual replenishments, of course, but no evident loss in lubrication value—that, in a word, is the experience of an eastern power plant using Bowser filters.

Analysis by chemists told this story:

The specific gravity Baumé is a shade higher, the flash point 5 degrees higher, the fire point 15 degrees higher, the viscosity 5 seconds more than the three wholly new samples tested for comparison, and the cold test the same.



This is a splendid example of Bowser filtration service, and we welcome such facts and figures to corroborate thousands of similar experiences. Indeed, in every line of endeavor today Bowser filtration system is doing its full part to maintain entire lubrication efficiency.

If you are seeking dependable efficiency in this direction, and want to profit by the experience of others in your own line, invite a Bowser engineer to present the facts. Address Dept. 70.

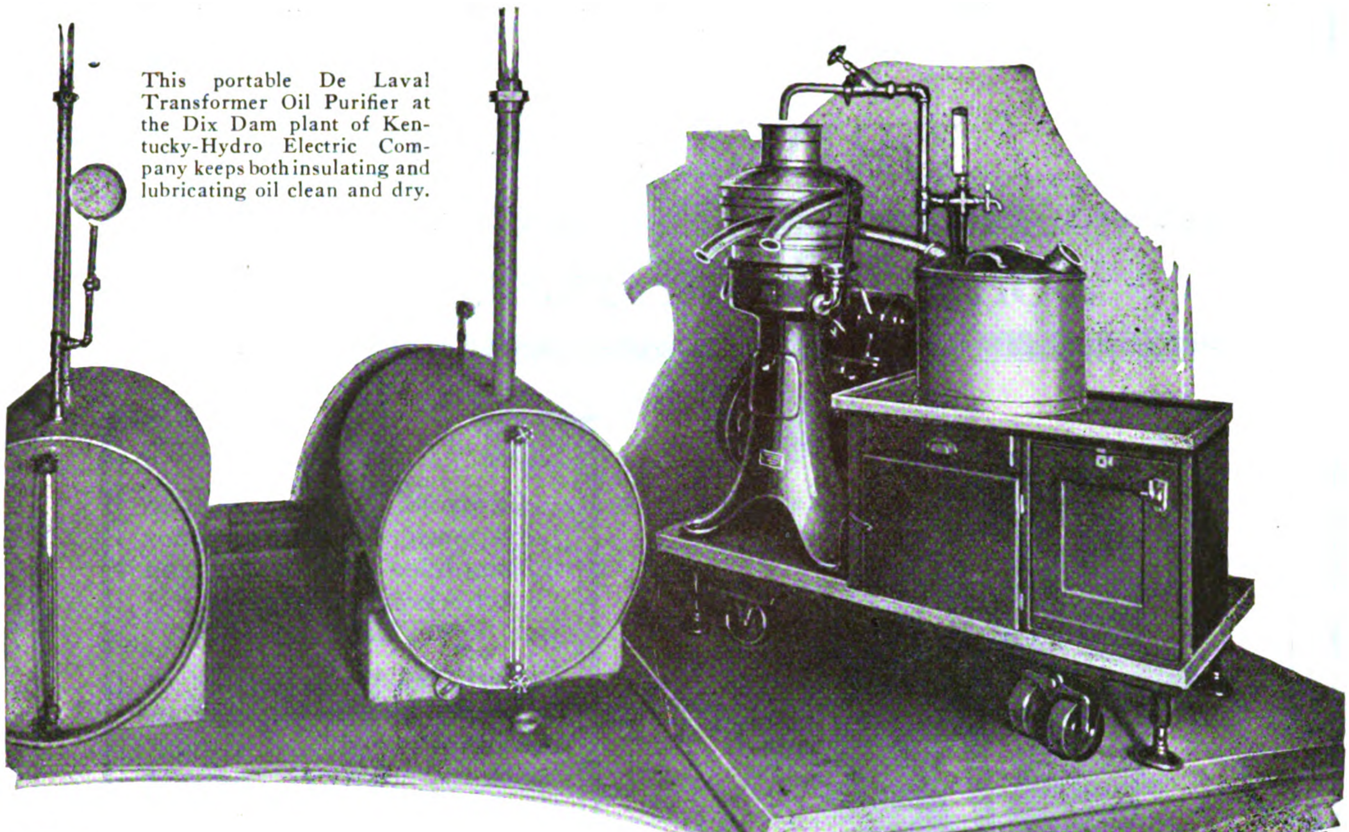
We will be at the Chicago Power Show, Febrary 14th to 18th in Booth No. 164.

CHICAGO POWER SHOW FEB. 14-18

S. F. BOWSER & COMPANY, Inc.

LUBRICATION ENGINEERS AND MANUFACTURERS

FORT WAYNE, INDIANA, U.S.A.



This portable De Laval Transformer Oil Purifier at the Dix Dam plant of Kentucky-Hydro Electric Company keeps both insulating and lubricating oil clean and dry.

Clean, dry oil for Dix Dam plant

Oil used at the Dix Dam plant of the Kentucky-Hydro Electric Company is maintained at high efficiency by means of the portable De Laval Transformer Oil Purifier shown above. A good part of the time the machine is operated as a stationary unit in the oil room, but it is a simple matter to move it alongside a transformer or oil circuit breaker which needs dehydrating, or for that matter, to take it to another plant miles away.

Here as in hundreds of other plants it has been shown that a De Laval enables oil to be maintained at the highest degree of purity at much less cost and with much less trouble than is otherwise possible, for centrifugal dehydration is positive and rapid and does not require the services of an expert.

In most industrial plants there are other oils which can be purified by the same machine with two-fold economy—improved lubrication and lower oil consumption.

We shall be pleased to tell you how a De Laval will soon pay for itself in your own plant. In writing please ask particularly for Bulletin 106-I on lubricating and fuel oil or Bulletin 107-I on transformer and circuit breaker oil.

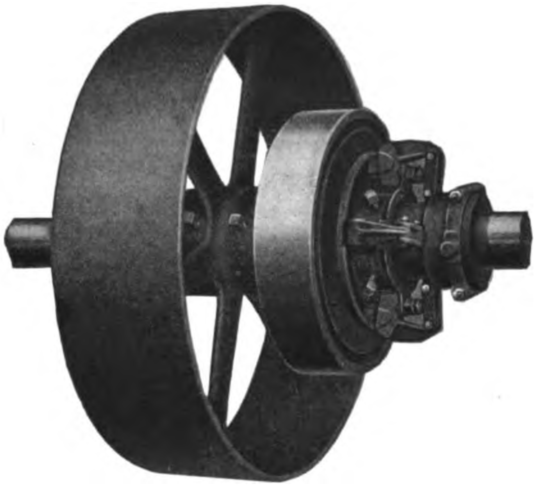
THE DE LAVAL SEPARATOR COMPANY
165 Broadway, New York 600 Jackson Blvd., Chicago
DE LAVAL PACIFIC COMPANY, 61 Beale St., San Francisco
ALFA-LAVAL CO. Ltd., 34 Grosvenor Road, London, S. W. 1.

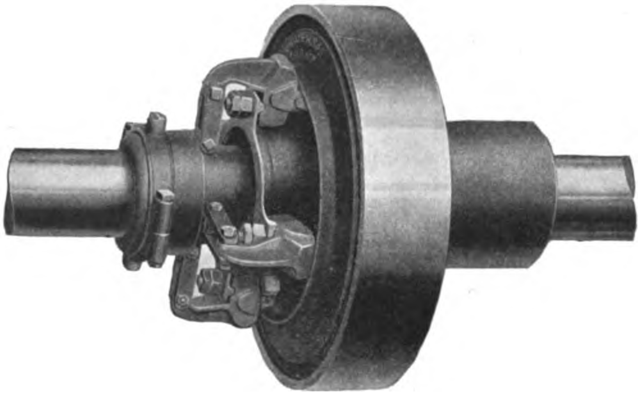
De Laval Oil Purifiers

Types for Lubricating Oil, Fuel Oil, Transformer and Circuit Breaker Oil, Crankcase Oil

DRIVE RIGHT!

Control Your Horsepower





Control your developed horsepower as you do your automobile—with a Friction Clutch—only make certain it is a "UNIVERSAL GIANT."

With it you can start or stop any one or all of your machines at will and without shock by the simple process of throwing a lever.

As a safety device the "U.G." Clutch gives full control of all moving shafts or machines. Costly shut-downs and their consequent delays may be avoided.

Builders of machine tools are incorporating the "U.G." as standard equipment in their product.

It will pay you to investigate the "U.G.", there will be no obligation.

SEVENTY YEARS of SERVICE
1857 1927
T. B. WOOD'S SONS CO.
POWER TRANSMISSION MACHINERY
CHAMBERSBURG, PA.

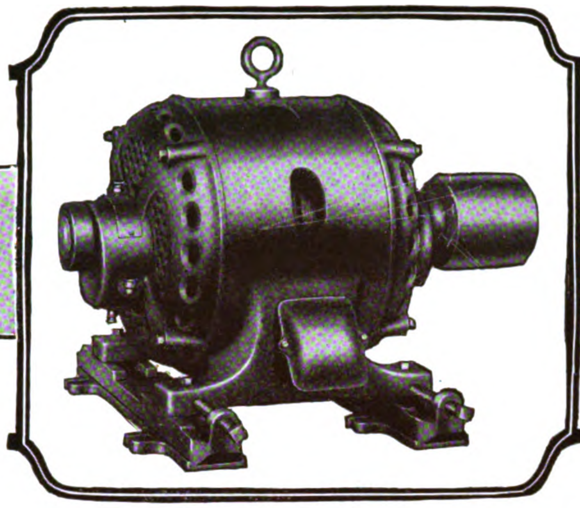
T. B. WOOD'S SONS CO.
Chambersburg, Pa.

New England Branch: Cambridge, Mass.
Southern Office: Greenville, S. C.

Wood's Power
Transmission Machinery

Shafting	Pulleys
Hangers	Pillow Blocks
Couplings	Belt Contactors
Rope Drives	Speed Reducers
Friction Clutches	Conveyors

Ball Bearings



7½ Horse Power Century Type SC Squirrel Cage Induction 3 and 2 Phase Motor

Continuity of Service

The long, uninterrupted service which users of Century Type SC Squirrel Cage Induction 3 and 2 Phase Motors experience, results from liberal proportions, with proper mechanical and electrical design and allocation of active materials.

Additional desirable features which contribute to their "Keep a-Running" ability are:

1 . . Armatures are practically indestructible. The copper bars and end rings are brazed over an area approximately six times their cross section.

2 . . Bearings last under severe service. They are made from cast phosphor bronze, machined to micrometer limits—and provided with machine-cut figure-8 oil grooves.

3 . . Field coils withstand the dampness of humid, tropical climates because they are insulated with moisture resisting material and the completed winding saturated with insulating compound.

Century Type SC Squirrel Cage Induction 3 and 2 Phase Motors are built in all standard sizes from ¼ to 75 horse power. Under normal operating conditions temperature rise is not more than 40° Centigrade.

CENTURY ELECTRIC CO. *1806 Pine Street* ST. LOUIS

33 Stock Points in the United States and More Than 50 Outside Thereof

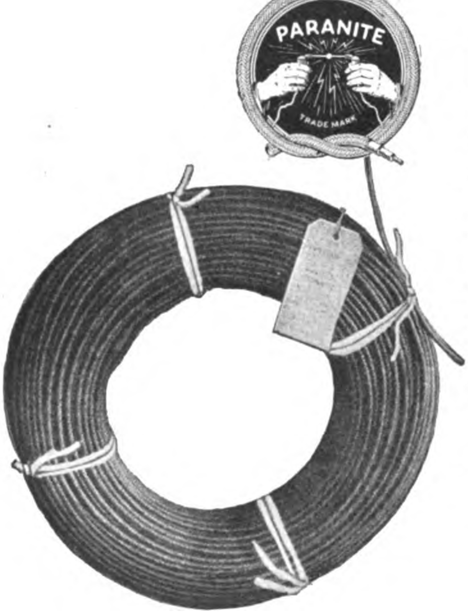
"They Keep a-Running"

¼ to 75 H. P.

Century MOTORS

¼ to 75 H. P.

No job is better than the wire that forms its foundation



POOR wire never yet made a good wiring job. No matter how expertly the work is done, if the wire isn't *right* the whole installation suffers. Someone is likely to be blamed for "faulty wiring" when the true trouble is *faulty wire*.

That's why contractors, industrial engineers, architects—all who specify and use rubber covered wires—insist on PARANITE. When a business reputation is at stake it isn't prudent to gamble with wire.

Into every roll of PARANITE we've built 37 years of experience and experiments. And back of it all, is an unrelenting determination to make our product increasingly better. That's why PARANITE stays always a pace ahead of the procession.

INDIANA RUBBER & INSULATED WIRE COMPANY
JONESBORO, INDIANA

811 Marquette Bldg.
Chicago, Illinois

63 Vesey Street
New York City

Western Representative

H. F. Boardman
400 Hibernian Bldg., Los Angeles

Walter I. Ferguson & Company
208 Baltimore Bldg., Kansas City, Mo.

Warehouse stocks Dallas, Texas; Denver, Colorado

If it's

PARANITE

it's Right

The Best Evidence

one can have of the merits or demerits of a thing is its actual performance

We don't ask you to believe ONE word in this advertisement.

VIM leather belting is perfectly able to do its own talking.

It has been our highest ambition to produce a belt superior in every respect to any other on the market. We have not spared time, labor, or money in perfecting our VIM tanning process, its remarkable performance and economy.

Compare VIM and oak leather on an emery wheel in this way.

The unanimous verdict of leather experts all over the world is that mineral tanned leather is more durable than vegetable tanned.

VIM leather is a special mineral tan.

There is a Houghton Man in your vicinity. Have him call and tell you what VIM is doing for others in your industry.

You can get much instructive reading on belts from our booklet, "The Belt that puts the pull in the Pulley." The coupon below will bring you a copy.

E. F. HOUGHTON & CO.
P. O. Box 6913, North Philadelphia, Pa.
AND ALL OVER THE WORLD

Fill in, Tear off, and Mail

E. F. Houghton & Co.
P. O. Box 6913, North Philadelphia, Pa.

Please send me a copy of "The Belt that puts the pull in the Pulley" without obligating me in any way.

Name ....

Firm ....

Position ....

Address ....

Remarks ....

IE

ARMSTRONG

DROP-FORGED WRENCHES

"The best wrench made, Mr. Gray"

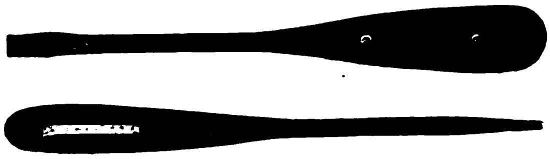
Experienced workmen will give you the same story time after time—the story of satisfactory, lasting service under the hardest usage.

Use ARMSTRONG Drop-Forged Wrenches for Satisfaction and Economy!

Write for Catalog B-27, showing complete ARMSTRONG Line of Quality Tools. Sent free on request.

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
318 N. Francisco Avenue
CHICAGO, U. S. A.

Screw "LENOX" Drivers



Long Life is Built In

"LENOX" Screw Drivers are forged in one piece from handle to tip, of the highest quality special analysis steel.

Points are heat treated to stand the strain without bending. And the handles cannot loosen.

Every "LENOX" is guaranteed unconditionally. Order a box from your dealer today.

AMERICAN SAW & MFG. CO.
Springfield, Mass.
"The Tools in the Plaid Box"

Standardized testing

—*an assurance of uniform high quality*

Throughout the process of manufacture, all raw materials, every product used in producing Micanite and Empire insulations, as well as the finished insulations, are tested in strict accordance with the standards of the American Society for Testing Materials.

That is why the electrical, physical and chemical characteristics of Micanite and Empire are always uniform and dependable.

Standardized testing is but one phase of the modern scientific manufacture that produces "the always dependable insulation." Empire and Micanite mean assured quality.

MICA INSULATOR COMPANY

World's Largest Manufacturers of Mica Insulation

Sole Mfrs. of Micanite, Super and Empire Electrical Insulation

New York: 68 Church Street   Chicago 542 So. Dearborn Street

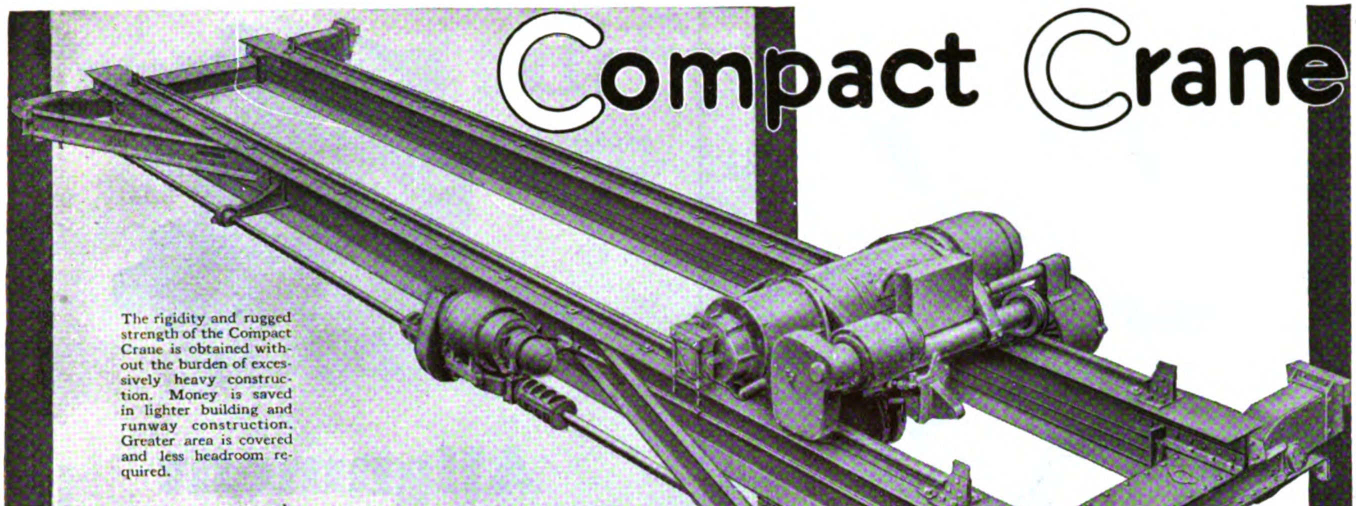
Works: Schenectady, N. Y.; Victoriaville, Canada; London, England

Cleveland   Pittsburgh   Cincinnati   Seattle   San Francisco   Los Angeles

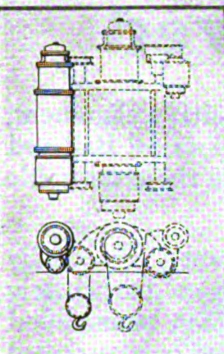
PERFECT MICANITE INSULATOR REG. U.S. PAT. OFF.   Electrical INSULATION   PERFECT EMPIRE INSULATOR REG. U.S. PAT. OFF.

MICA INSULATION   OILED CLOTH INSULATION

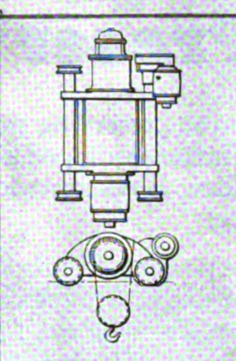
Compact Crane



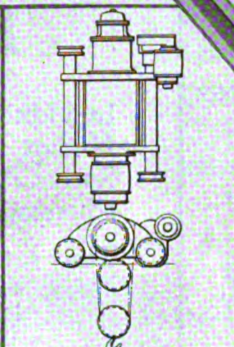
The rigidity and rugged strength of the Compact Crane is obtained without the burden of excessively heavy construction. Money is saved in lighter building and runway construction. Greater area is covered and less headroom required.



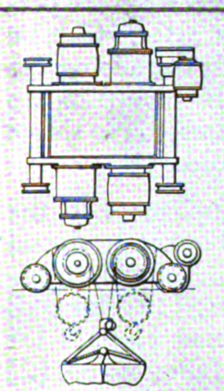
Auxiliary Hoist
can be attached to any Shepard Crane Trolley



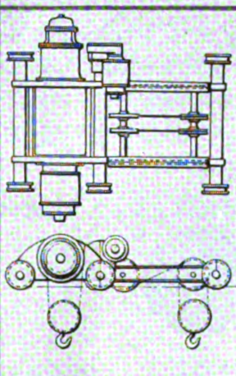
Standard
1 and 2 part double reeving, for many general purposes.



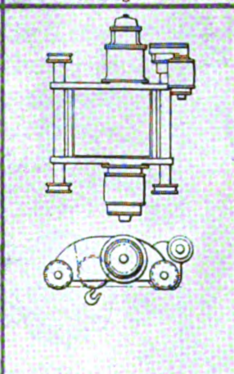
Standard
3 and 4 part double reeving. Extra long drum furnished for long lifts.



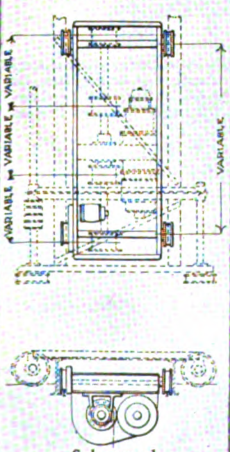
Double Hook
2 hoisting units of equal capacity, for grab buckets and double hook service.



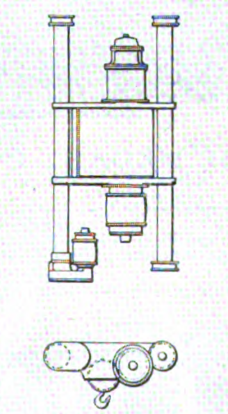
Extension
2 hooks for lifting simultaneously at two points long loads parallel to crane girders.



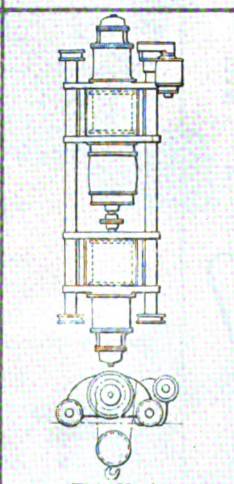
Close Lift
Permits hook to come close to trolley rail.



Submerged
Runs between and on the lower flanges of two I-beam girders.



Close Clearance
Permits location of trolley rail close to ceiling or roof.



Twin Hook
Two drums and two hooks operating simultaneously and at right angles to trolley rail.

with a trolley specially suited to each job

—minus a special job price

A Compact Crane Trolley has unusual strength and rigidity. The load carrying frame is all steel construction. The girts are box section steel castings, connected by a body piece of wrought steel plate, securely riveted or welded and amply braced on the underside. Axle brackets of heavy seamless drawn steel tubes carry the frame.

A sectionalized design affords a trolley arrangement to suit precisely your plant and load-moving conditions—a few of the many adaptations are shown.

Let a Shepard representative explain fully the advantages of this unique design and its economy.

SHEPARD ELECTRIC CRANE & HOIST CO.
415 Schuyler Ave., Montour Falls, N. Y.

SHEPARD
ELECTRIC CRANES & HOISTS

Largest Manufacturer of Electric Hoists in America

Branch offices are maintained in principal cities

New Nuttall Speed Reducers

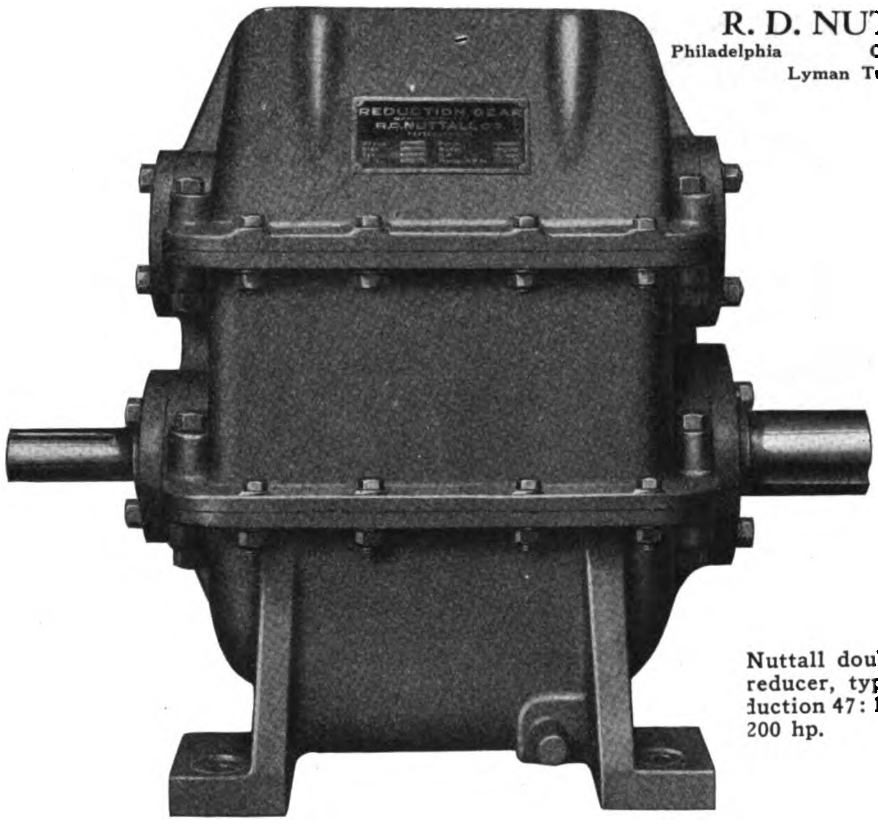
Helical Gears
Timken Roller Bearings
Positive Lubrication

The new Nuttall helical gear speed reducers are simply and ruggedly constructed. They have but few parts to wear and get out of order. They are built to operate continuously, and even under the most adverse conditions to require no attention beyond the occasional addition of oil to the case.

Helical gears give great strength and smooth operation; Timken roller bearings insure bearing dependability; the rigid reinforced case assures perfect alignment of shafts and gears even under great stress; and the Nuttall system of positive splash lubrication reduces maintenance to the very minimum.

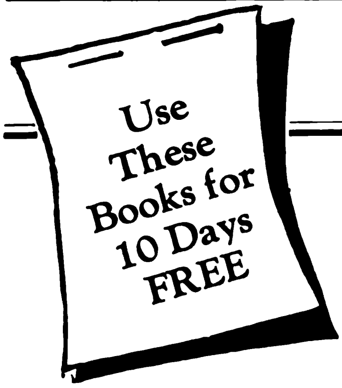
Send for our Speed Reducer Bulletin

R. D. NUTTALL CO., Pittsburgh, Pa.
Philadelphia Chicago Wilkes-Barre Los Angeles
Lyman Tube & Supply Co., Montreal, Canada



Nuttall double reduction speed reducer, type DVR. Max. reduction 47:1; Max. horse power 200 hp.

Nuttall



This library answers all the repair and winding problems that the electrician will meet in actual practice

THESE five volumes contain the largest collection of practical methods for electrical repair and maintenance men ever put together in book form.

The books cover every phase of electrical repair and maintenance work from armature winding to the correction of brush troubles. And the treatment is always from the practical man's standpoint.

These five books will help the young repairmen to absorb knowledge that could be secured otherwise only through many years of experience.

The older and more experienced repairman will find the books a valuable and handy source of reference as a supplement to his own knowledge.

Electrical Maintenance and Repair

5 Volumes—1736 pages—1810 illustrations—7c. a day

EVERY man concerned with the care and repair of electrical machinery should have these practical books, with their helpful tables, diagrams, data, methods and kinks.

Every one of the five volumes is jammed to the covers with sound, how-to-do-it information—the kind you have to have when anything goes wrong.

Liberal use has been made of practical data and practice in repair shops so as to combine the good features of a library of methods with handbook information covering these methods.

In these books will be found answers to practically all the repair and winding problems that the electrician will meet in actual practice.

Every phase of electrical maintenance and repair work covered

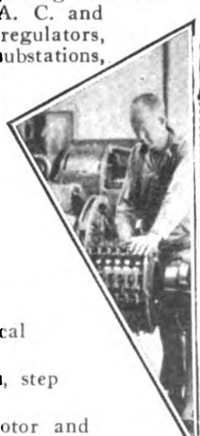
The books discuss direct and alternating current windings—repair shop methods for rewinding armatures—commutator connections—the testing of armature windings—the testing of induction motors for faults—practical ways of reconnecting induction motors—commutator repairs—correcting brush troubles, etc.

They tell you how to inspect and repair motor starters and generators—how to diagnose motor and generator troubles—how to figure new windings for old cores on induction motors.

You learn about three-wire systems, starting rheostats, transformers and starting polyphase motors, etc.

They give you scores of practical methods used by electrical repairmen to solve special problems.

The books contain hundreds of photographs, diagrams and tables. There are wiring diagrams covering A. C. and D. C. generators, feeders, transformers, potential regulators, synchronous converters, batteries and boosters, substations, lamp mechanism connections, rheostats and controller, lightning arresters, automatic switches, railway controllers, etc.



Practical how-to-do-it books

The five volumes in this library are how-to-do-it books in every sense of the word.

They deal with the everyday work of electrical maintenance and repair.

They discuss actual repair jobs and show you, step by step, what to do when anything goes wrong.

They show you how to locate and remedy motor and generator troubles.

They show you how to reconnect motors to meet any condition of voltage, phase, frequency and speed.

They give you suggestions for preventing electrical machinery troubles.

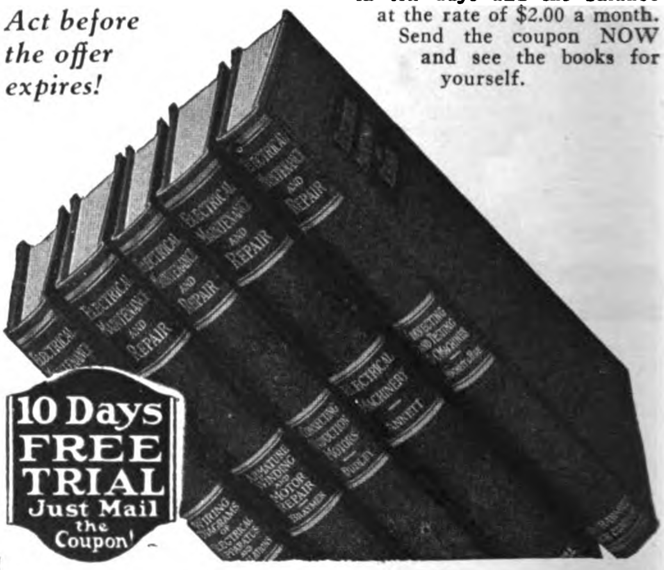
They cover fully the rewinding of motors.

They present information that will help you get better service out of electrical equipment and machinery.

$2.00 a month pays for this 5-volume library

Fill in and mail the coupon attached and we will send you the entire set of five volumes for ten days' Free Examination. We take all the risk—pay all charges. You assume no obligation—you pay nothing unless you decide to keep the books. Then $2.00 in ten days and the balance at the rate of $2.00 a month. Send the coupon NOW and see the books for yourself.

Act before the offer expires!



FREE EXAMINATION COUPON

McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York.

Gentlemen:—Send me the New Library of Electrical Maintenance and Repair, all charges prepaid for 10 days' Free Examination. If satisfactory I will send $2.00 in ten days and $2.00 a month until $14.00 has been paid. If not wanted I will write for shipping instructions.
(IMPORTANT—To secure books on approval write plainly and *fill in all lines.*)

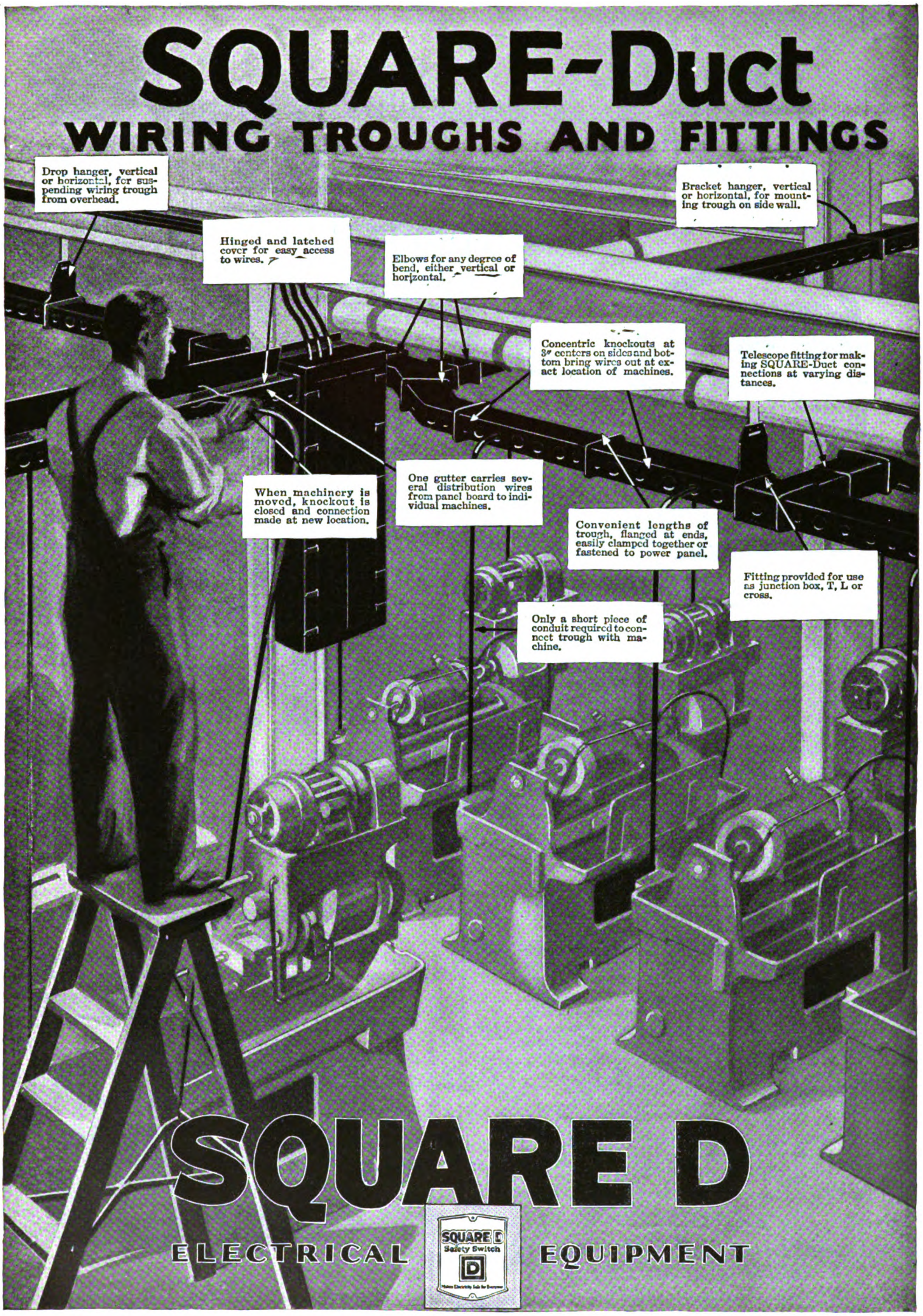
Name ....

Home Address ....

Name of Company ....

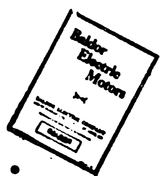
Occupation ....

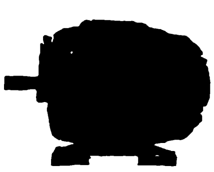
IE-12-27



SQUARE-Duct
WIRING TROUGHS AND FITTINGS
Drop hanger, vertical or horizontal, for suspending wiring trough from overhead.
Bracket hanger, vertical or horizontal, for mounting trough on side wall.
Hinged and latched cover for easy access to wires.
Elbows for any degree of bend, either vertical or horizontal.
Concentric knockouts at 3" centers on sides and bottom bring wires out at exact location of machines.
Telescope fitting for making SQUARE-Duct connections at varying distances.
When machinery is moved, knockout is closed and connection made at new location.
One gutter carries several distribution wires from panel board to individual machines.
Convenient lengths of trough, flanged at ends, easily clamped together or fastened to power panel.
Fitting provided for use as junction box, T, L or cross.
Only a short piece of conduit required to connect trough with machine.
SQUARE D
ELECTRICAL EQUIPMENT
SQUARE D Safety Switch
D

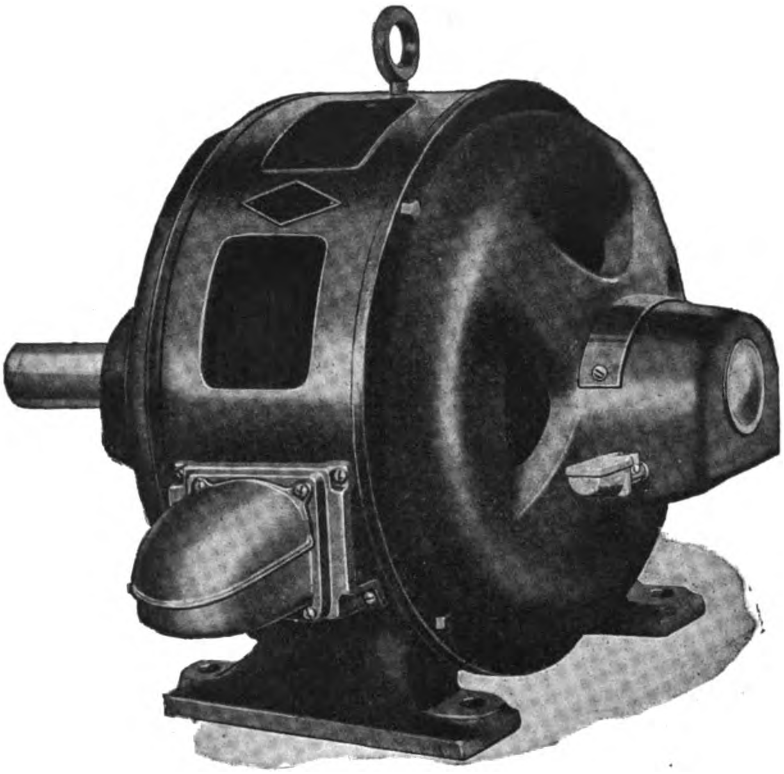
(118)





Imperial Motors Are Quiet, Smooth-Running and Dependable

36 Years' Experience Building Good Motors



SQUIRREL CAGE MOTOR

Invite Us To Discuss Your Motor Problem With You

Built On a Business Creed of "Quality, Service, Right Prices, Courteous Treatment"

The Imperial Electric Co.

FACTORY-AKRON, OHIO.

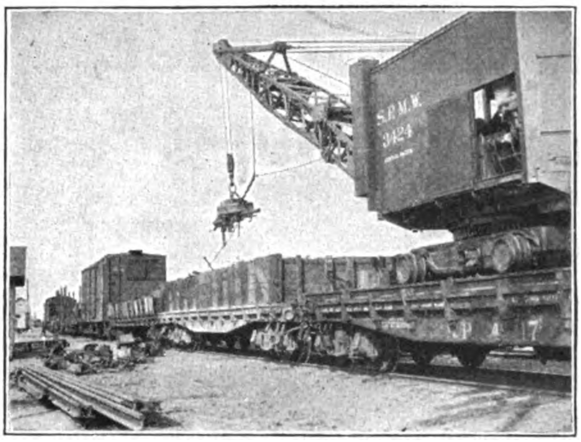
MANUFACTURER, SINCE 1889, of MOTORS and GENERATORS for EVERY PURPOSE

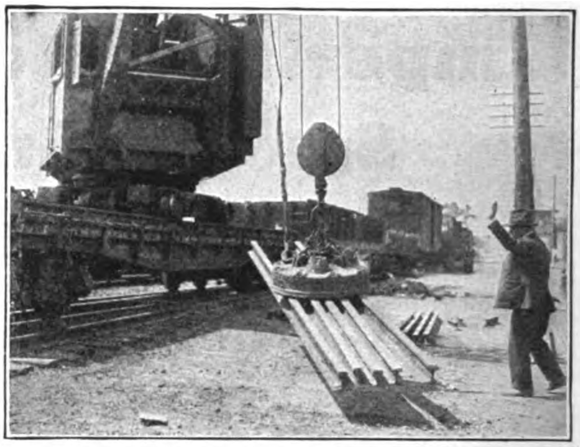
QUALITY ÷ SERVICE + RIGHT PRICES -÷- COURTEOUS TREATMENT

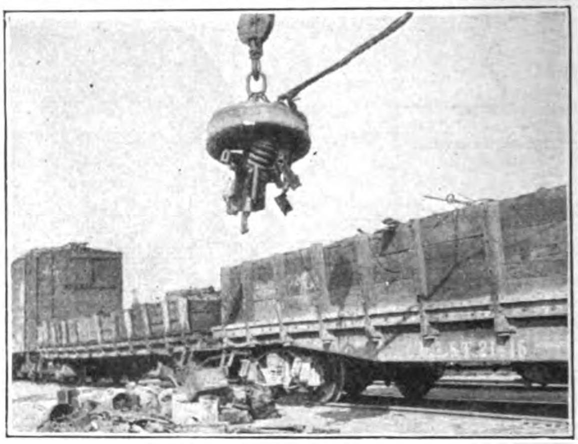
BRANCHES

NEW YORK, N.Y. Park-Murray Bldg. — CHICAGO, ILL. 9 So. Clinton St. — MLWAUKEE, WIS. 236 - 24th St. — COLUMBUS, O. 319 Citizens Bank Bldg. — ST. LOUIS, MO. 301 Buder Bldg. — CLEVELAND, O. Rockefeller Bldg.

PHILADELPHIA, PA. 2019 Rittenhouse St. — GRAND RAPIDS, MICH. 336½ Michigan Trust Bldg. — CINCINNATI, O. Greenwood Bldg. — PITTSBURGH, PA. 705-5th Ave. Arcade Bldg. — DETROIT, MICH. 100 Morgan Bldg.





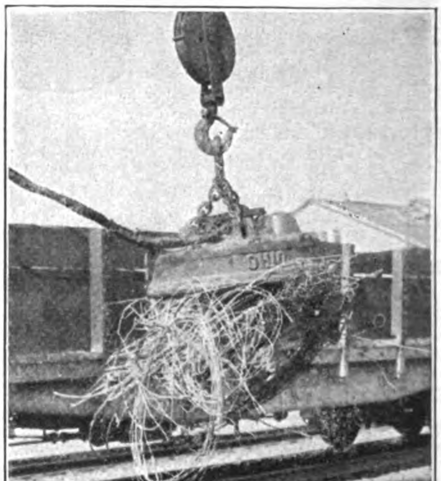


These pictures show a 36" diameter Ohio Magnet handling a variety of materials from wire to steel rails easily and with no complaint if worked 365 days (of 24 hours) per year.

The magnet automatically rejects any copper, brass or babbit which can then be collected and sold at appropriate prices.

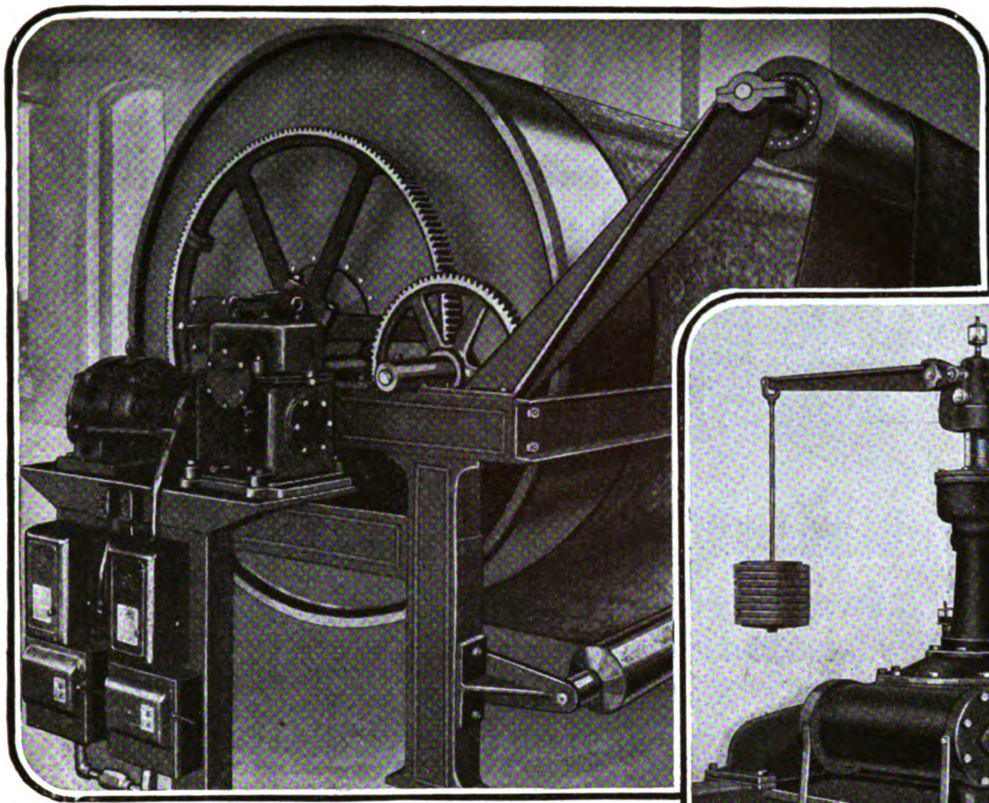
Ohio Magnet Outer Rings are solid, they very seldom break. All insulation is asbestos. Upkeep cost is very low.

Have you a Magnet Problem?

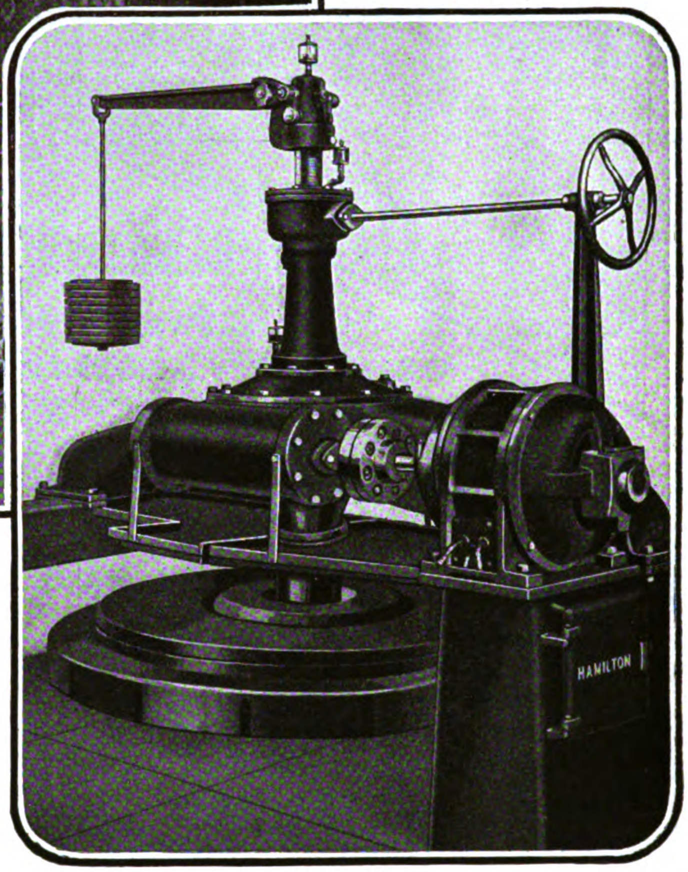


OHIO
reliable
MAGNETS

The
Ohio Electric & Controller Co.
5910 Maurice Ave.
Cleveland, Ohio



Below: Standard Cleveland Worms and Gears are furnished in this grinder head for a plate glass finishing machine. Ratio 33½ :1, 20 hp., 865 r.pm. Each machine is equipped with twenty-five of these heads.



Above: Standard Cleveland Worm Gear Reduction Unit built into the drive of a carpet steaming and drying machine. Ratio 8¾ :1, 5 hp., 1,200 r.p.m.

Lad talks in parables.

"Here, Lad—

you claim that the Lincoln people have hit on a wonderful idea in motor construction. How come that something new in a motor, one of the oldest and most thoroughly developed pieces of electrical apparatus, should so suddenly be discovered?"

"Easy, Pop—

stockings were invented in the eleventh century but they weren't discovered until the twentieth.

There have been too many cast iron petticoats on motors in the past—all following a rigid fundamentalism in design.

The Lincoln people in this 'Linc-Weld' motor got rid of cast iron construction—put in muscular shafts and masculine bearings to keep down bearing troubles—piled in plenty of active materials and better insulation. But they didn't make a new motor—just made it according to modern principles with a betterment of the older principles—pulled out the cast iron petticoats that warmed up the old motors—put in welded steel which let in the air.

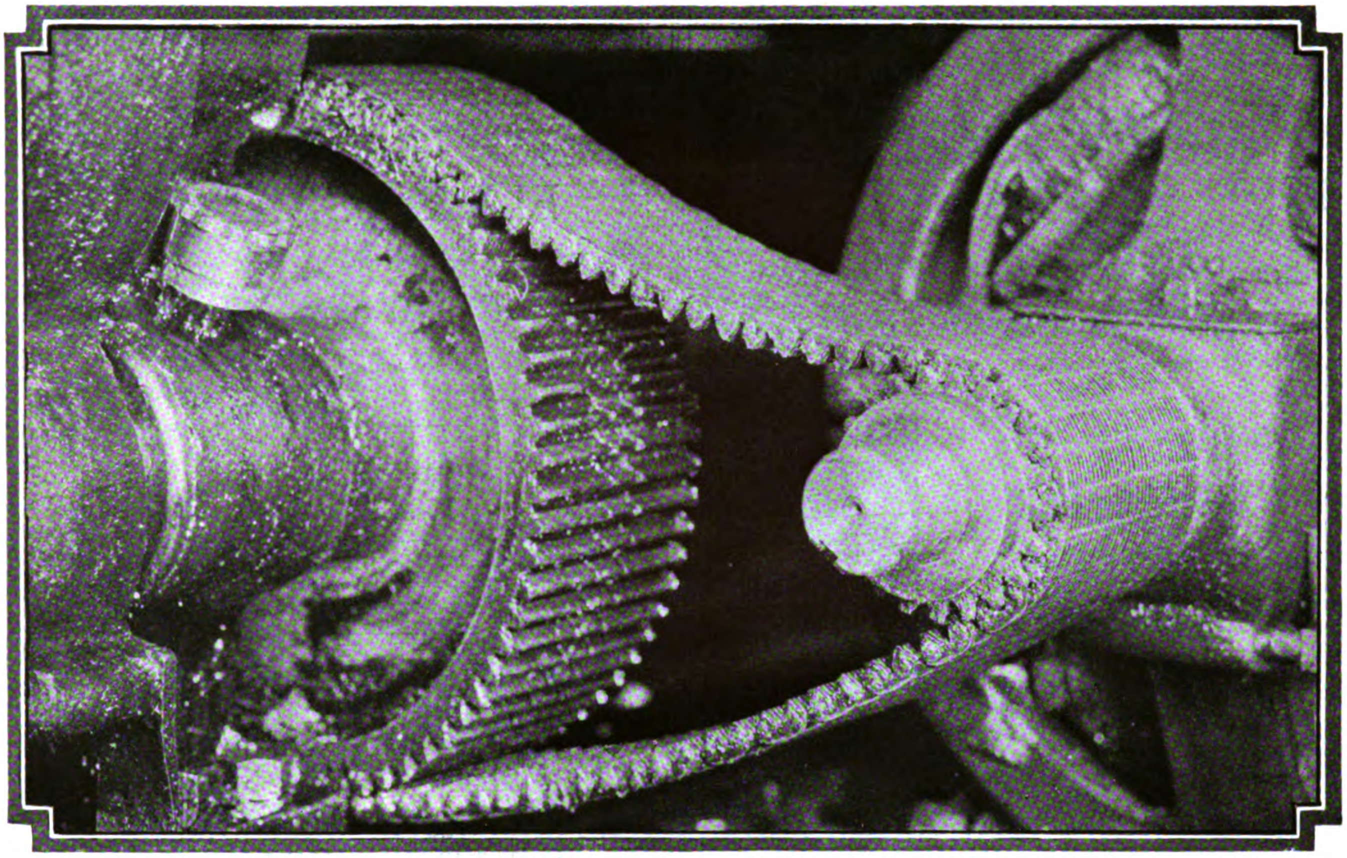
In other words, they gave the motor a chance to step—with pep."

The Lincoln Electric Co., Dept. No. 5-12, Cleveland, Ohio

M-4

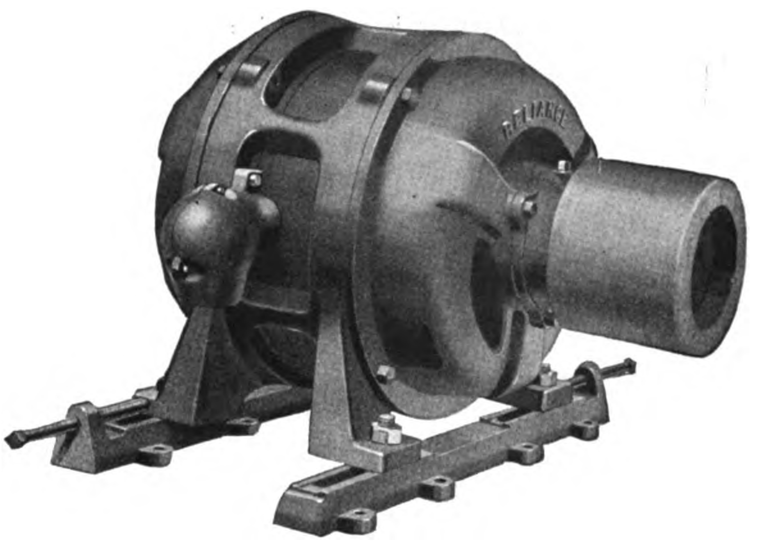
"Linc-Weld"

LINCOLN MOTOR



Buy this motor~

and junk the Oil Can!



The oil can and its contents though essential to the ordinary motor are two of its worst enemies. Too much oil carelessly directed causes oil-soaked windings and costly breakdowns.

With Reliance Ball-bearing Motors on the job you can cut out the danger and cut down the cost at the same time. In place of frequent oil squirting apply a little grease once a year. The grease is easily put where it belongs and can be kept there. Breakdowns due to oil-soaked windings are at an end.

The Reliance ball-bearing motor construction is backed by 21 years of experience in applying anti-friction bearings to electric motors.

CHICAGO POWER SHOW FEB. 14-18

RELIANCE ELECTRIC & ENGINEERING CO.
1051 Ivanhoe Road, Cleveland, Ohio
Branches: Boston, New York, Buffalo, Pittsburgh, Philadelphia, Birmingham, Cincinnati
Detroit, Chicago

RELIANCE A-C D-C MOTORS

WITH BALL BEARINGS

F-R-I-C-T-I-O-N

that old bogey of power transmission

can be materially reduced—unnecessary power losses can be cut down—with

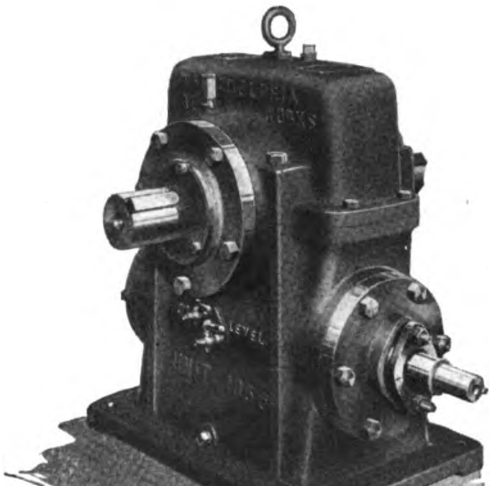
Philadelphia
SPEED REDUCING UNITS

Just to give one example:

Ball or Roller Bearings are used on the shafts of Philadelphia Units and all moving parts operate in an "oil bath." All the gears used have perfect tooth contact and are made from the highest grade materials, specially treated to resist wear.

As all moving parts are completely housed, these units are unaffected by Dirt, Dust, Moisture and Acid Fumes.

And, with these Speed Reducing Units you can use the economical "High Speed" Motors.



NOTE: There's a Philadelphia Unit for every purpose: Worm, Herringbone, and Spur Types; Straight Line, Right Angle or Vertical Drives.

P. S.—We've been making all sizes and types of Gears for nearly 50 years. "Send for the Gear Book."

Speed Reducers
are the ideal drive for:

Rotary Kilns
Screw Conveyors
Agitators
Ball Mill Feeders
Hydrators
Rotary Dryers
Bag Cleaners
Slurry Tanks
Grizzlies
Crushers
Feeder Loaders
Mechanical Stokers
Elevators

Main Office and Plant Erie Ave. and G St. Phila., Pa.

PHILADELPHIA GEAR WORKS

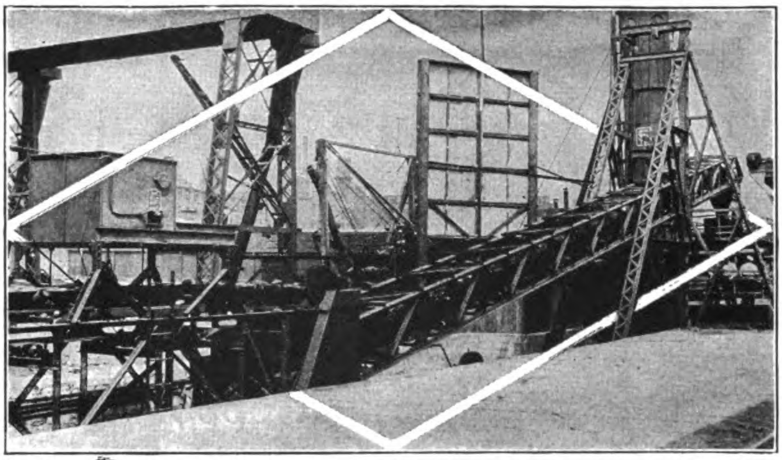
Manufacturers of Industrial Gears and Speed Reducing Units

PHILADELPHIA, PENNA.

Branch Sales and Engineering Office: 12 E. 41st St., New York

50% of the handling cost SAVED

. . . and 50% of coaling-time!



THIS coal-handling installation — made by the Webster Manufacturing Co., of Chicago, and equipped with Diamond Rubber Belts—consists of two belt conveyors 40" wide; one horizontal and one inclined.

The horizontal conveyor carries the coal from the storage bin to the inclined conveyor, which discharges directly into the bunkers of the vessel alongside the wharf.

Both conveyors are movably mounted in a steel frame which operates on a track; the inclined conveyor can be raised or lowered according to the freeboard of the vessel being coaled. Coal is automatically sprinkled and weighed. There is no breakage.

The installation attracts all the customers it can serve, because vessels will not wait for slower, old-fashioned coaling. Investigate the possibilities of Diamond Conveyor Belts for *your* business.

THE DIAMOND RUBBER COMPANY, Inc., Akron, Ohio

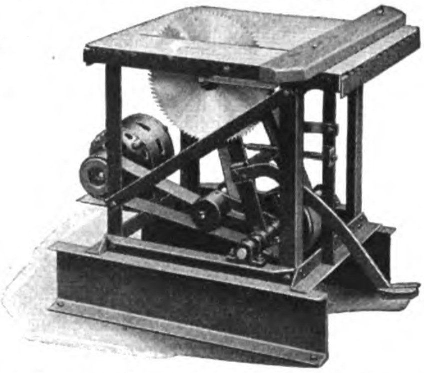
Atlanta Boston Kansas City New York Philadelphia
Chicago Dallas Los Angeles Seattle San Francisco

Diamond

Rubber Belting ~ Hose • Packing

Cut your crating costs with the Parks "Clipper"

$165.00
with 2 H. P. motor



Swing cut-off and rip saw built for heavy duty. Big work—little price! Guaranteed 10 years. Your present crating cost will show you need this saw. It will do more work than an extra man and pay its small first cost in a few weeks.

Send the coupon for complete specifications today!

PARKS
WOODWORKING MACHINES

FILL OUT AND MAIL THIS COUPON—NOW!

I.E.

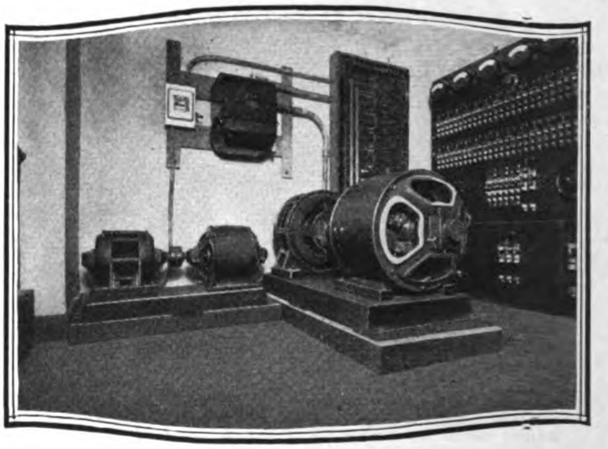
The Parks Wood-Working Machine Co.
1600 Knowlton Street,
Cincinnati, Ohio

Send specification sheet on Parks "Clipper" factory saw.

Name . . . .

Address . . . .

City . . . . State . . . . . .



DIEHL MOTOR GENERATOR SETS

Diehl motor generator sets are used for many purposes ranging from supplying direct current for laboratory uses in schools to operating heavy magnet cranes. In Diehl motor generator sets are incorporated many exclusive features combined with rugged construction, high electrical efficiency and ample ventilating and lubricating facilities. Diehl engineers can help you with your motor problems.

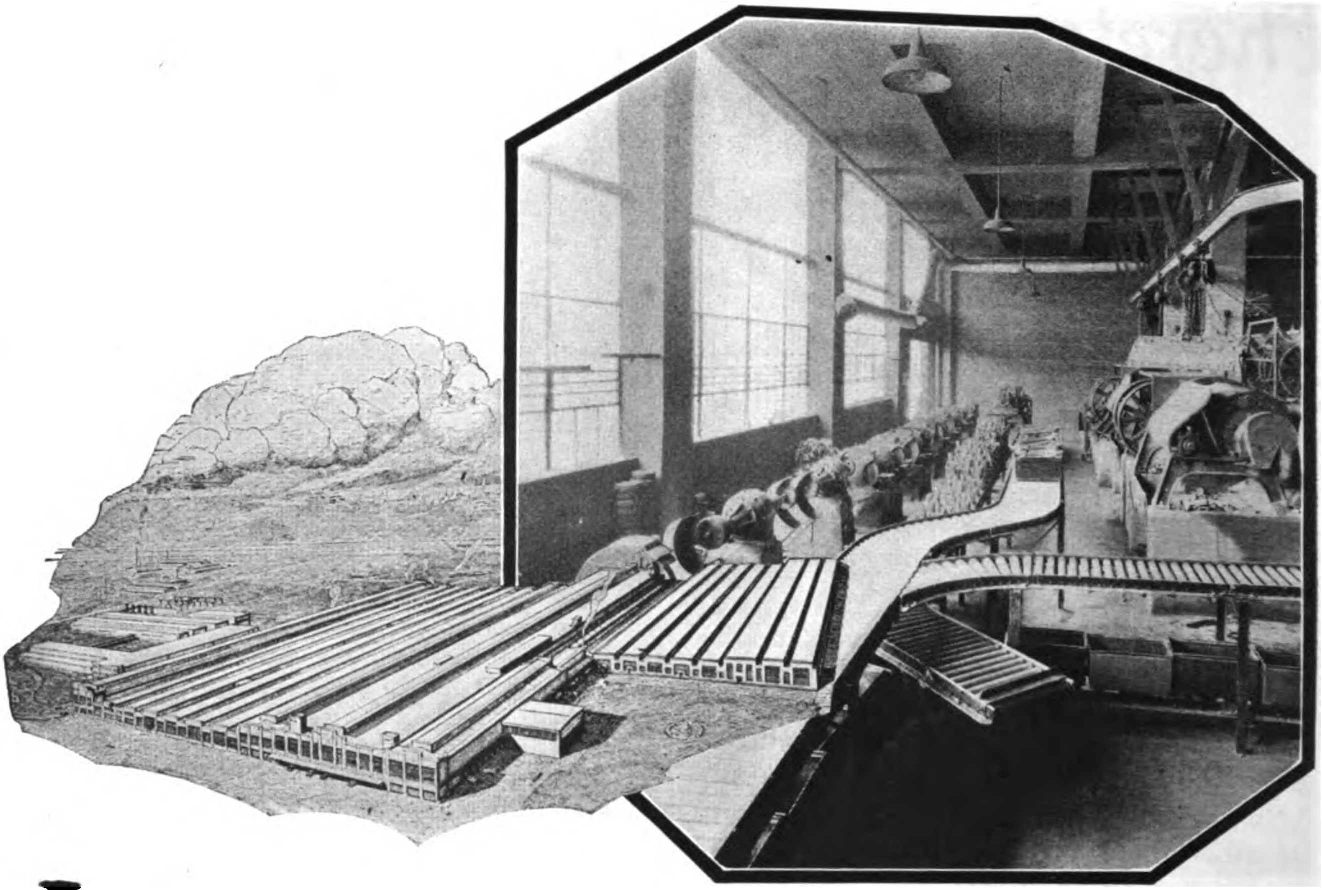
Write for descriptive bulletins—now

DIEHL MANUFACTURING CO.
ELIZABETHPORT, N. J.

Atlanta Boston Chicago Detroit New York Philadelphia

D I E H L

BUILDERS OF FANS AND MOTORS SINCE 1888



Low cost mileage—a Standard Conveyor feature

Day and night in automotive production, tons of metal are transported over miles and miles of Standard Conveying Systems.

The maintenance men in automotive plants have a comparatively simple job in operating these conveyors. The reports they turn in show great ease of maintenance.

Standard Conveying Systems require only systematic greasing. For example the Nash maintenance man has perfected his system concerning which there are some interesting facts.

The bearings in the rollers have an exceptionally long life even though they sustain the entire working load of the conveyor and are in constant motion. The Chrysler engineer has some interesting facts regarding this.

Replacements of both bearings and rollers are simple to make, taking little time and effort and causing no serious delays on the assembly line.

Our handling counselors can propose good maintenance checking factors for you.

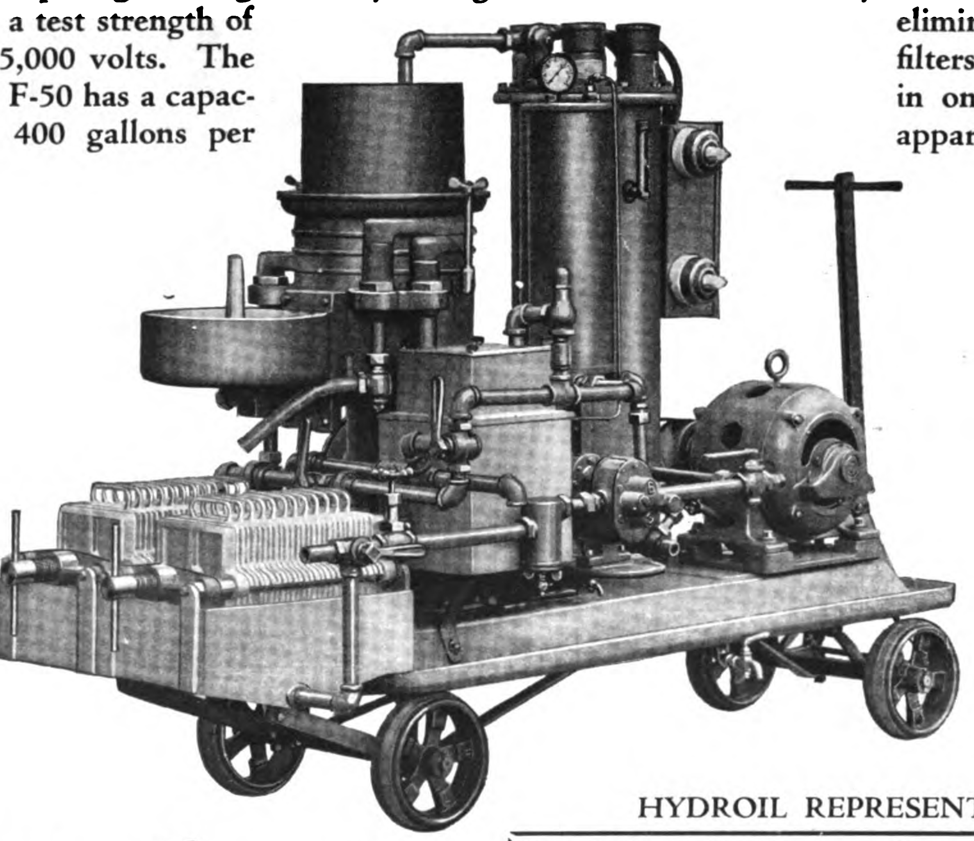
Interesting facts on maintenance savings through Standard Conveyor Systems in the Automotive field can be mailed to you.

STANDARD
CONVEYOR COMPANY
NORTH ST. PAUL, MINNESOTA

For Plant Efficiency—
Purify Switch Breaker and Transformer Oil the HYDROIL Way

Industrial plants with numerous oil switches and circuit breakers or large batteries of transformers will be interested in the Model F-50 Hydroil. Complete restoration of the dielectric strength in oil is attained in the shortest possible time. A single passage through the Hydroil gives the oil a test strength of over 25,000 volts. The Model F-50 has a capacity of 400 gallons per **hour, making it invaluable for emergency work such as cleaning the contents of large transformers with the minimum of service interruptions.**

A complete oil purifying service is obtained with the F-50 Hydroil Heaters, bowl, air-eliminating device and filters are all connected in one line. No extra apparatus is required.

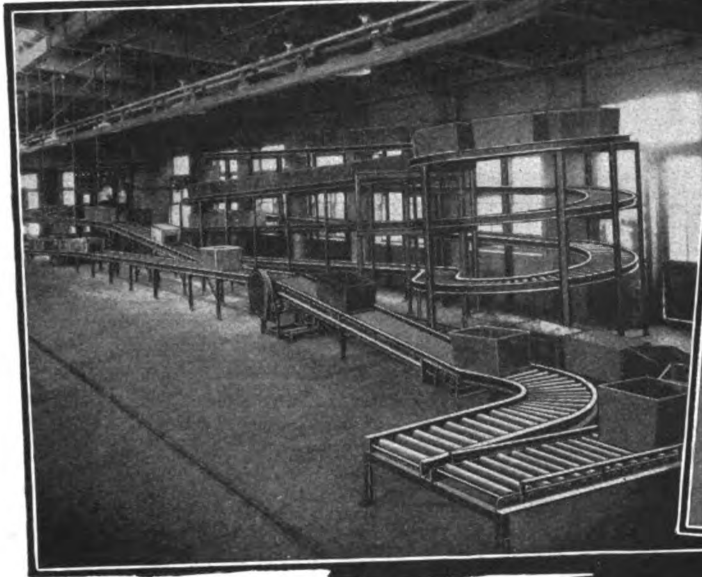


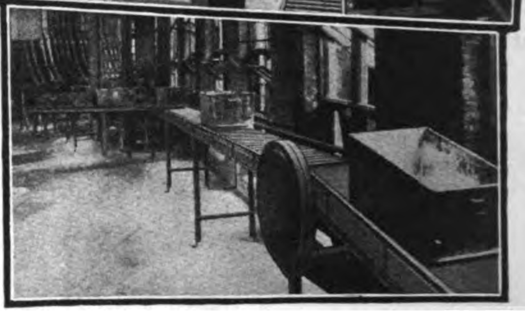
HYDROIL REPRESENTATIVES:

Power Equipment Company, 250 Stuart Street, Boston, Mass.	H. M. Thomas Company, 589 Howard St., San Francisco, Cal.
Lee Skipwith & Co., 369 Lexington Ave., New York, N. Y.	H. M. Thomas Company, (Mr. R. H. Ballock) 71 Columbia St., Seattle, Wash.
The Bradley Company, 2401 Chestnut St., Philadelphia, Pa.	Independent Electric Company, 603 Baker Bldg., Minneapolis, Minn.
E. S. Stickle Company, 40 West Seneca St., Buffalo, N. Y.	Powerlite Devices, Ltd., 124 Richmond Street, West, Toronto, Ontario, Canada.
E. S. Stickle Company 934 Union Trust Bldg., Pittsburgh, Pa.	E. S. Stickle Company, 342 Rockefeller Bldg., Cleveland, O.
Farnham & Cunningham 307 South Hill Street, Los Angeles, Calif.	

Hydroil
SALES CORPORATION
LEBANON, INDIANA

MANHATTAN RUBBER~*another user*





These four photographs show views of the Logan system in the Manhattan plant. Conveyors bring empty tote boxes to be filled with crude rubber, then forward them to refining operations. Each box is automatically weighed en route without removal from conveyor. Besides functioning as carriers between operations, long lines of Gravity Rollers serve as storage for rubber in process of tempering. In this comprehensive installation Logan Gravity Conveyors, Belt Conveyors and Vertical Elevators are used.

THEY *knew what they wanted!* The Manhattan Rubber Mfg. Co. is one of the world's leading makers of fine conveyor belts. Years of experience have naturally given them a wide knowledge of conveyors as well. They already appreciated the economical principle of mechanical handling and for the double assurance of dependable, care-free operation in their own plant they chose Logan Conveyors . . . . **For the same reason—the certainty of correct design and that element of plus service—leaders in every line of industry are using Logan Conveyors. Send for list of well-known users and your copy of "*Seven Economies of Logan Conveyors*". No obligations.**

Logan Co.

(Formerly THE DOW CO.)

512 N. Buchanan St. LOUISVILLE, KY.

Offices in Principal Cities

THE MANHATTAN RUBBER MFG. CO. PASSAIC, N.J.

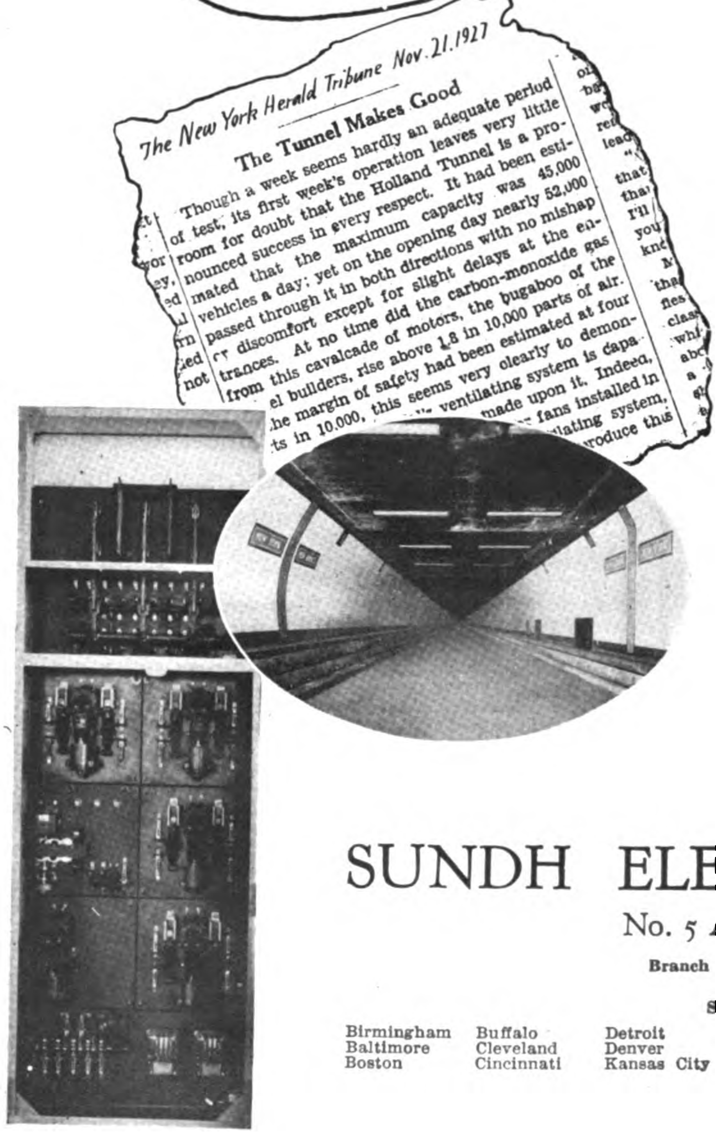
Slipless, stretchless and, best of all, practically wearless — Manhattan Conveyor Belts are outstandingly successful because they're made individually for particular jobs. Logan Conveyors are built on the same principle. Whatever you make or handle, there is a specialized Logan design that will fully meet your needs. Ask for an appointment with a Logan engineer.

Logan Conveyors
LOUISVILLE

Have you ever had a job like this

To engineer and design control for the ventilation of a project such as the new Holland Tunnels.

SUNDH did it!


The New York Herald Tribune Nov. 21. 1927

The Tunnel Makes Good

Though a week seems hardly an adequate period of test, its first week's operation leaves very little room for doubt that the Holland Tunnel is a pronounced success in every respect. It had been estimated that the maximum capacity was 45,000 vehicles a day; yet on the opening day nearly 52,000 passed through it in both directions with no mishap or discomfort except for slight delays at the entrances. At no time did the carbon-monoxide gas from this cavalcade of motors, the bugaboo of the ...el builders, rise above 1.8 in 10,000 parts of air. ...he margin of safety had been estimated at four ...ts in 10,000, this seems very clearly to demon... ventilating system is capa... made upon it. Indeed, ... fans installed in ...lating system, ...roduce this

This is only one of many large undertakings where Sundh engineering and apparatus has "made good."

The Business of Sundh is divided into Four Steps:

1. To find out conditions that actually exist.
2. To decide upon the equipment best suited to the job.
3. To build and assemble that equipment.
4. To deliver the equipment on time.

If you have not received a copy of the New Sundh Catalog you should do so by all means—write for your copy today.

SUNDH ELECTRIC COMPANY

No. 5 Ave. C, Newark, N. J.

Branch **Offices: Chicago, New York**

Sales Representatives:

Birmingham	Buffalo	Detroit	**Los Angeles**	**Omaha**	**Portland, Ore.**	**St. Louis**
Baltimore	Cleveland	Denver	**Minneapolis**	**Philadelphia**	**San Francisco**	**Montreal, Can.**
Boston	Cincinnati	Kansas City	**New Orleans**	**Pittsburgh**	**Seattle**	**Toronto, Can.**

LIGHT UP
and
Production
will Pick Up

American Adjustable Fixtures are now furnished with conduit fittings, permitting a neater, safer, more substantial job. Catalog gives full details. Copy free.

Do your men have to look twice at every measurement and adjustment because they can't trust their eyes? Install American Adjustable Fixtures at your machines and benches and production will be greatly increased as well as the quality of the work.

AMERICAN FIXTURE COMPANY

232 West Water St. **MILWAUKEE**

Write for Catalog and Prices

POWELL
PRESSED STEEL
MATERIAL HANDLING EQUIPMENT

You Save Their Cost Over and Over!

CONTINUOUS use in connection with any handling operation, soon reveals the basic economy of POWELL pressed steel Material Handling Equipment. Varied to meet any handling need—always giving maximum strength and service. Ask us for full details and prices now!

The **POWELL**
PRESSED STEEL CO.
HUBBARD, OHIO
Suburb of Youngstown

ROBINSON
Fans and Blowers

Adequate Air Man-Cooling Fans Brick Fans — Mine Fans Pressure Blowers Special Fans for Special Work.

Details on request

ROBINSON VENTILATING CO.
ZELIENOPLE, PA.

Business Wants

THE *Searchlight* Section of this paper represents a meeting place for men and concerns who have immediate business "wants" to fill—the section covers

Agencies Wanted	New Industries Wanted
Agents Wanted	Office Space for Rent or Wanted
Books and Periodicals	Partners Wanted
Business Opportunities	Patent Attorneys
Civil Service Opportunities	Patents for Sale
Contracts Wanted	Plants for Sale
Desk Room for Rent or Wanted	Positions Vacant
Educational	Positions Wanted
Employment Agencies	Property for Sale
Employment Service	Representatives Wanted
Foreign Business	Salesmen Available
For Exchange	Salesmen Wanted
For Rent	Spare Time Work Wanted
For Sale	Sub-Contracts Wanted
Franchises	Tutoring
Labor Bureaus	Vacation Work Wanted
Miscellaneous Wants	Work Wanted

"SEARCHLIGHT"

Elwell-Parker
Tin-Plate
ELECTRIC LIFT TRUCTOR

Picks Up
Tilts
Transports and Stacks

All accomplished electrically

Request details as to this new special, illustrated in Bulletin A535.

The Elwell-Parker Electric Co., Cleveland

WHAT AND WHERE TO BUY

Equipment, Apparatus and Supplies Advertised in this Issue with Names of Manufacturers and Distributors

Prospective purchasers in the electrical-mechanical market are invited to apprise us of their needs, assuming, of course, that the articles sought are not listed here.

Agitator Tanks
Paints, Rubber, Cement, etc.
Bowser & Co., S. F.
Agitators
New England Tank & Tower Co.
Air Compressors
Allis-Chalmers Mfg. Co.
Air Conveying Equipment
American Blower Co.
Buffalo Forge Co.
Air Filters
Midwest Steel & Supply Co.
Air Gap Gauges
Grinder Sales Co.
Air Washers, Coolers, Humidifiers
American Blower Co.
Buffalo Forge Co.
Ammeters, Voltmeters
(See Instruments, Electrical).
Armature & Field Testers
Martindale Electric Co.
Armature Coil Spreaders
Armature Coil Equipment Co.
Armature Coil Winders
Armature Coil Equipment Co.
Armature Repair Machinery
Armature Coil Equipment Co.
Armature Washing Fluid
Martindale Electric Co.
Armature Winders' Tools
Grinder Sales Co.
Armored Conductor
Tubular Woven Fabric Co.
Asbestos
Johns-Manville Co.
Babbitt
Magnolia Metal Co.
Barrels, Steel Shop
The Kirk & Blum Mfg. Co.
Batteries
Dry
National Carbon Co.
Battery Charging Apparatus
General Electric Co.
Westinghouse Electric & Mfg. Co.
Beads, Insulating
Martindale Electric Co.
Bearings
Chicago Pulley & Shafting Co.
Dodge Mfg. Corp.
Eureka Copper Prod. Corp.
Royersford Fdry. & Mach Co.
Trester Service Electric Co.
Webster Mfg. Co.
Wood's Sons Co., T. B.
Aligning
Fafnir Bearing Co.
Angular Contact
Fafnir Bearing Co.
Anti-Friction
Fafnir Bearing Co.
Armature
Fafnir Bearing Co.
Ball
Ahlberg Bearing Co.
Fafnir Bearing Co.
Hyatt Roller Bearing Co.
New Departure Mfg. Co.
Norma Hoffmann Co.
Wood's Sons Co., T. B.
Motor
Norma Hoffmann Co.
Precision
Norma Hoffmann Co.
Roller
Ahlberg Bearing Co.
Hyatt Roller Bearing Co.
Norma Hoffmann Co.
Royersford Fdry. & Mach Co.
Timken Roller Bearing Co.
Tapered
Timken Roller Bearing Co.
Thrust
Fafnir Bearing Co.
Norma Hoffmann Co.
Timken Roller Bearing Co.
Bearing Metal
Dodge Mfg. Corp.
General Electric Co.
Magnolia Metal Co.
Westinghouse Electric & Mfg. Co.
Belt, Cement
Schieren Co., Chas. A.
Belt Contactors
Wood's Sons Co., T. B.
Belt Dressing
Cling Surface Co.
Schieren Co., Chas. A.
Standard Oil Co., Ind.
Belt Drivers
Smidth & Co., F. L.
Belting
Alexander Bros., Inc.
Chicago Pulley & Shafting Co.
Houghton & Co., E. F.
I. B. Williams & Sons
Leather
Schieren Co., Chas. A.
Leather Link
Schieren Co., Chas. A.
Waterproof Leather
Schieren Co., Chas. A.

Belts, Conveyor
Diamond Rubber Co.
Link-Belt Co.
Webster Mfg. Co.
Belts, Elevator
Diamond Rubber Co.
Belts, Transmission
Diamond Rubber Co.
Link-Belt Co.
Bleachers
Worcester Bleach & Dye Works Co.
Blocks, Pillow
Chicago Pulley & Shafting Co.
Fafnir Bearing Co.
Jones Fdry. & Mach. Co.,
Medart Co.
Webster Mfg. Co.
Blow Torches
McGill Mfg. Co.
Blowers
American Blower Co.
Buffalo Forge Co.
Breuer Elec. Mfg. Co.
Clements Mfg. Co.
De Laval Steam Turbine Co.
Kirk & Blum Mfg. Co.
Martindale Electric Co.
Sturtevant Co., B. F.
Centrifugal
De Laval Steam Turbine Co.
Electric
Breuer Elec. Mfg. Co.
Electric Portable
Breuer Elec. Mfg. Co.
Clements Mfg. Co.
Blow-Pipe Systems
The Kirk & Blum Mfg. Co.
Bobs
Philadelphia Gear Works
Bolts, Nuts and Screws
Sturtevant Co., B. F.
Bonds, Rail
Ohio Brass Co.
Books
McGraw-Hill Book Co.
Boosters
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.
Boxes
Conduit
Appleton Electric Co.
Colt's Patent Fire Arms Mfg. Co.
McGill Mfg. Co.
Floor Outlet
Adam Electric Co., Frank
Harvey Hubbell, Inc.
Hanger
Fafnir Bearing Co.
Junction and Outlet
Appleton Electric Co.
General Electric Co.
Harvey Hubbell, Inc.
Trumbull Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.
Meter and Service
Colt's Patent Fire Arms Mfg. Co.
General Electric Co.
Trumbull Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.
Sectional Switch and Outlet
Appleton Electric Co.
Sheet Metal Tote
The Kirk & Blum Mfg. Co.
Brackets, Instrument
Trumbull Elec. Mfg. Co.
Brake Drums, Hardened
Tool Steel Gear & Pinion Co.
Brakes
Electric Controller & Mfg. Co.
Westinghouse Electric & Mfg. Co.
Disc
Westinghouse Electric & Mfg. Co.
Electric
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
Westinghouse Electric & Mfg. Co.
Brooms & Brushes
Osborn Mfg. Co.
Brushes
Trester Service Electric Co.
Carbon
Baylis Co., The
Boxill-Bruel Carbon Co.

Commutator
Carbon Engrg. Co.
Eureka Copper Products Corp.
General Electric Co.
Morganite Brush Co., Inc.
National Carbon Co.
Ohio Carbon Co.
Westinghouse Electric & Mfg. Co.
Dynamic and Carbon
Morganite Brush Co., Inc.
National Carbon Co.
Ohio Carbon Co.
Westinghouse Eectric & Mfg. Co.
Gauze Wire Dynamo
Martindale Electric Co.
Generator
Ohio Carbon Co.
Slip Ring
Ohio Carbon Co.
Brush Holders
Baylis Co., The
Electric Accessories Co.
Eureka Copper Products Corp.
Westinghouse Electric & Mfg. Co.
Bus Bar Supports
General Electric Co.
Railway & Ind. Engrg. Co.
Westinghouse Electric & Mfg. Co.
Bushings
Appleton Electric Co.
Eureka Copper Products Corp.
Porcelain
Ohio Brass Co.
Cables (See Wire & Cable)
Cable Accessories
Dossert & Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.
Cableways
Williamsport Wire Rope Co.
Car Movers
Powell & Son, G. D.
Carbon Brushes
(See Brushes)
Carbons
Contact
Ohio Carbon Co.
Elevator
Ohio Carbon Co.
Welding
Ohio Carbon Co.
Casters
Bassick Co.
Castings, Die
Magnolia Metal Co.
Castings, Steel
Falk Corp.
Cement, High Pressure
Johns-Manville Co.
Centrifugal Separators
Hydroil Sales Corp.
Centrifugals
De Laval Separator Co.
Chains
Outo Engine
Ramsey Chain Co.
Automobile Timing
Ramsey Chain Co.
Auto Transmissions
Ramsey Chain Co.
Automotive Replacement
Ramsey Chain Co.
Block
Whitney Mfg. Co.
Compensating Joint
Ramsey Chain Co.
Drive
Ramsey Chain Co.
Flat Tink
Ramsey Chain Co.
Roller
Whitney Mfg. Co.
High Speed, Silent Running
Ramsey Chain Co.
Silent
Whitney Mfg. Co.
Silent Transmission
Ramsey Chain Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 142.

Sprocket Wheel (Silent Drive)
Ramsey Chain Co.
Steel
Ramsey Chain Co.
Transmission
Ramsey Chain Co.
Chains, Power Transmission
Diamond Chain & Mfg. Co.
Link-Belt Co.
Morse Chain Co.
Philadelphia Gear Works
Ramsey Chain Co.
Webster Mfg. Co.
Whitney Mfg. Co.
Circuit Breakers
Condit Electrical Mfg. Co.
Cutler-Hammer Mfg. Co.
Cutter Co.
General Electric Co.
Roller-Smith Co.
Sundh Electric Co.
Westinghouse Electric & Mfg. Co.
Clamps
General Electric Co.
Railway & Ind. Engrg. Co.
Westinghouse Electric & Mfg. Co.
Cleaners, Metal Waste,
General
Oakite Products, Inc.
Cleats
Square D. Co.
Clutches,
Dodge Mfg. Corp.
Chicago Pulley & Shafting Co.
Reeves Pulley Co.
Webster Mfg. Co.
Friction
Allis-Chalmers Mfg. Co.
Jones Fdry. & Mach. Co., W. A.
Link-Belt Co.
Wood's sons Co.,
Magnetic
Cutler-Hammer Mfg. Co.
Coal and Ash Handling Equipment
Dodge Mfg. Corp.
Link-Belt Co.
Webster Mfg. Co.
Coil Winding Machines
Armature Coil Equipment Co.
Coil Winding Tools
Grinder Sales Co.
Coils
Choke
American Transformer Co.
General Electric Co.
Railway & Ind. Engrg. Co.
Westinghouse Electric & Mfg. Co.
Coils, Induction
American Transformer Co.
Combinations, Switch, Choke Coil or Fuse
Railway & Ind. Engrg. Co.
Commutator Cement
Green Equipment Co.
Commutator Cleaner
Martindale Electric Co.
Commutator Equipment
Ideal Commutator Dresser Co.
Commutator Grinding Tools
Ideal Commutator Dresser Co.
Martindale Electric Co.
Commutator Slot Varnish
Martindale Electric Co.
Commutator Slotting Files
Martindale Electric Co.
Commutator, Slotting Machines
Martindale Electric Co.
Commutator Slotting Saws
Martindale Electric Co.
Commutator Stones
Green Equipment Co.
Grinder Sales Co.
Ideal Commutator Dresser Co.
Martindale Electric Co.
Commutators
Cleveland Armature Works
Commutators and Parts
Eureka Copper Products Corp.

Compensators
Automatic
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Electric & Mfg. Co.
Manual
Allis-Chalmers Mfg. Co.
Cutler-Hammer Mfg. Co.
General Eectric Co.
Industrial Controller Co.
Westinghouse Electric & Mfg. Co.
Compressors, Centrifugal
De Laval Steam Turbine Co.
Cocrete Floor
Sonneborn Sons, Inc., L.
Concrete Inserts
Midwest Steel & Supply Co.
Conductors, Armored
Tubular Woven Fabric Co.
Conduit Fittings
Appleton Electric Co.
Conduits
Tubular Woven Fabric Co.
Wiremold Co.
Interior, Fibre and Underground
Johns-Manville Co.
Connectors and Terminals
Dossert & Co.
General Electric Co.
Ohio Elect. & Cont. Co.
Westinghouse Electric & Mfg. Co.
Contact Rail Insulators
Ohio Brass Co.
Control Systems
Kimble Electric Co.
Controller Parts
Eureka Copper Products Corp.
Controllers
Armored for Electric Circuits
Ohio Elec. & Controller Co.
Automatic
Allen-Bradley Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Kimble Electric Co.
Lewellen Mfg. Co.
Rowan Controller Co.
Russell Mfg. Co.
Sundh Electric Co.
Westinghouse Electric & Mfg. Co.
Crane
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
Sundh Electric Co.
Electric
Industrial Controller Co.
Ohio Elect. & Cont. Co.
Finger
Russell Mfg. Co.
Machine Tool
Sundh Electric Co.
Manual
Industrial Controller Co.
Sundh Electric Co.
Motor
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Condit Electric Mfg. Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Kimble Electric Co.
Lewellen Mfg. Co.
Rowan Controller Co.
Russell Mfg. Co.
Square D. Co.
Sundh Electric Co.
Union Electric Co.
Westinghouse Electric & Mfg. Co.
Reversible
Russell Mfg. Co.
Speed
Kimble Electric Co.
Temperature and Pressure
Taylor Instrument Co.
Conveyors
Link-Belt Co.
Logan Co.
Palmer-Bee Co.
Richards-Wilcox Mfg. Co.
Webster Mfg. Co.
Wood's Sons Co., T. B.
Gravity
Standard Conveyor Co.
Coolers, Air
American Blower Co.
Buffalo Forge Co.
Copper Slotting Cutters
Hullhorst-Micro Tool Co.
Cord, Flexible
Harvey Hubbell, Inc.
Okonite Co., The
Rome Wire Co.
Simplex Wire & Cable Co.
Tubular Woven Fabric Co.

SEARCHLIGHT SECTION

EMPLOYMENT-BUSINESS OPPORTUNITIES-EQUIPMENT

UNDISPLAYED—RATE PER WORD:

Positions Wanted, 4 cents a word, minimum 75 cents an insertion, payable in advance.

Positions Vacant and all other classifications, 8 cents a word, minimum charge $2.00.

Proposals, 40 cents a line an insertion.

INFORMATION:

Box Numbers in care of any of our offices count 10 words additional in undisplayed ads.

Discount of 10% if one payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:

1 to 3 inches	$5.00 an inch
4 to 7 inches	4.80 an inch
8 to 14 inches	4.60 an inch

An advertising inch is measured vertically on one column, 3 columns—30 inches—to a page.

I. E.

EMPLOYMENT SERVICE

IF you are qualified for position between $2,500 and $25,000, and are receptive to negotiations for new connections, your response to this announcement is invited. The undersigned provides a thoroughly organized service, established seventeen years ago, to conduct confidential preliminaries, and assist the qualified man in locating the particular position he desires. Not an employment agency. Retaining fee protected by refund provision, as stipulated in our agreement. Send name and address only for description of service. R. W. Bixby, Inc., 258 Main Street, Buffalo, New York.

EMPLOYMENT AGENCY

POSITION open for industrial and maintenance engineers, works managers, superintendent, production managers and time study men, draftsmen and designers. No registration fee. Free service to employers. Write Consolidated Agencies, formerly H. H. Harrison and Co., 110 South Dearborn St., Chicago.

POSITIONS WANTED

ELECTRICAL engineer; eighteen years' experience, capable of laying out, installing and maintaining plants, have handled men for past fifteen years. Married. Would like to take charge of electrical construction and maintenance in an industrial plant. Location immaterial. Employed but available within a month. PW-262, Industrial Engineering, 1600 Arch St., Phila., Pa.

POSITIONS WANTED

AT present employed but desire to make change; age 33; experience 15 years electrical maintenance and construction work, 4 years of this time on electric welding equipment; capable of handling men and running job; ten years with present employer. PW-263, Industrial Engineering, Guardian Bldg., Cleveland, Ohio.

CHIEF electrician, 38, married, with fifteen years' experience on maintenance and installation, desires permanent position; technical education. PW-264, Industrial Engineering, Tenth Ave. at 36th St., New York.

ELECTRICIAN, 14 years' experience A.C.-D.C., capable of taking charge, desires position in East. Married, age 31. PW-265, Industrial Engineering, Tenth Ave. at 36th St., New York.

PLAN NOW FOR THE FUTURE—
Train to be a **Meter Engineer!**

Competent meter engineers earn from $3,000 to $5,000 a year! The demand for thoroughly trained men is constant. Get into this profitable and fascinating profession now. Our home study course will train you quickly and start you on the road to a larger salary as a meter expert. It has been prepared by authorities and has the recognition of the largest Public Utility Companies as the most practical course. FREE BOOKLET—get the facts now! Write for our interesting descriptive booklet. Sent free without obligation to you.
Fort Wayne Correspondence School
Dept. 82, Ft. Wayne, Indiana

FREE BULLETINS

GREGORY ELECTRIC CO., 16th and Lincoln Sts., Chicago, Ill.—The November issue of this company's monthly bargain sheet of hi-grade rebuilt motors and electrical machinery has just been issued. A special announcement accompanying this booklet states that "this issue contains the most complete and drastic downward revision of prices in our history."

HYMAN-MICHAELS CO., Peoples Gas Bldg., Chicago, Ill.—Bulletin 140, just issued, is a 16-page list of used machinery and equipment suitable for mines, mills, plants and contractors, offered from the company's plants in St. Louis, East Chicago, San Francisco, Seattle and Portland.

BARGAINS IN

FREQUENCY CHANGERS

for high speed woodworking machinery.

PLATING GENERATOR SETS

50 to 6000 amperes.

SLOW SPEED MOTORS

The Motor Repair & Mfg. Co.
Cleveland, Ohio

OVER 12,000 other men in responsible charge of Operation & Maintenance work in Industrial Plants of every variety throughout the country, will see these pages—

Then isn't this the logical place to advertise any business wants you may have of interest to operation and maintenance men?

EMPLOYMENT — BUSINESS — EQUIPMENT OPPORTUNITIES, ETC., ETC., ETC.

Cotton Yarns
Worcester Bleach & Dye Works Co.

Counters
Veeder Mfg. Co.

Coupling Boxes
Tool Steel Gear & Pinion Co.

Couplings,
Wood's Sons Co., T. B.
Flexible
Allis-Chalmers Mfg. Co.
Chicago Pulley & Shafting Co.
De Laval Steam Turbine Co.
Dodge Mfg. Corp.
Falk Corp.
Foote Bros. Gear & Mach. Co.
Jones Fdry. & Mach. Co.,
Nuttall Co., R. D.
Palmer-Bee Co.
Philadelphia Gear Works
Smith & Serrell
Shaft
Wood's Sons Co., T. B.

Crankcase, Oil Reclaimer
De Laval Separator Co.

Crane Controllers
Allen-Bradley Co.

Crane Motors
Kimble Electric Co.
Sundh Electric Co.
Westinghouse Electric & Mfg. Co.

Crane Gears, Hardened
Tool Steel Gear & Pinion Co.

Crane Wheels, Hardened
Tool Steel Gear & Pinion Co.

Cranes, Electric
Triumph Electric Co.

Cranes, Portable Electric
Elwell-Parker Co.
Shepard Elec. Crane & Hoist Co.

Crating Saws
Parks Woodworking Machine Co.

Cutouts
Arrow Electric Co.
Colt's Patent Fire Arms Mfg. Co.
General Electric Co.
Harvey Hubbell, Inc.
Square D. Co.
Trumbull Elec. & Mfg. Co.
Westinghouse Electric & Mfg. Co.

Cutters
Commutator Slotting
Hullhorst Micro Tool Co.
Key-Seat
Whitney Mfg. Co.

Cutting Compound
Oakite Products, Inc.

Diagrams
McGraw-Hill Book Co.

Doors, Sliding
Richards-Wilcox Mfg. Co.

Doorways
Richards-Wilcox Mfg. Co.

Drills
Buffalo Forge Co.

Drives
Smidth & Co., F. L.
Rope
Wood's Sons Co., T. B.
Short Center
Wood's Sons Co., T. B.
Short Center—Leather Belt
Bird Machine Co. (Pulmax Drive)
Silent Chain
Grant Gear Works, Inc.
Link-Belt Co.
Whitney Mfg. Co.

Drying Apparatus
Buffalo Forge Co.

Dust Collecting Systems
Kirk & Blum Mfg. Co.

Dynamos
(See Generators & Motors)

Electric Arc Welding Machines
Resistance Type
Ohio Brass Co.

Electric Etchers
Martindale Electric Co.

Electric Lighting
Westinghouse Electric & Mfg. Co.

Elevator Control & Switchboard Washers
Grinder Sales Co.
Dodge Mfg. Corp.

Elevators & Conveyors
Dodge Mfg. Corp.
Link-Belt Co.
Webster Mfg. Co.

Engines
Oil
American Blower Co.
Allis-Chalmers Mfg. Co.
Steam
Buffalo Forge Co.

Extractors, Centrifugal
De Laval Separator Co.

Factory & Foundry Equipment
Osborn Mfg. Co.

Fan Hangers, Electric
Adam Electric Co., Frank

Fan Motors
Century Electric Co.
General Electric Co.
Kimble Electric Co.
Kirk & Blum Mfg. Co.
Westinghouse Electric & Mfg. Co.

Fans
American Blower Co.
Buffalo Forge Co.
Diehl Mfg. Co.
National Screw & Mfg. Co.
Disc
Robinson Ventilating Co.
Exhaust and Ventilating
Century Electric Co.
General Eectric Co.
Kimble Electric Co.
The Kirk & Blum Mfg. Co.
Sturtevant Co., B. F.
Westinghouse Electric & Mfg. Co.
Turbine
Robinson Ventilating Co.

Fibre Wedge Drivers
Grinder Sales Co.

Files, Commutator Slotting
Martindale Electric Co.

Filters
Continuous for Turbines
Bowser & Co., S. F.
Transformer Oil
Bowser & Co., S. F.

Fixtures, Lighting
American Fixture Co.
McGill Mfg. Co.
Miller Co.
Westinghouse Electric & Mfg. Co.

Flexible Shaft Machinery, Portable
Haskins & Co., R. G.

Friction Clutches
Foote Bros. Gear & Mach. Co.

Furnaces, Electric
General Electric Co.
Westinghouse Electric & Mfg. Co.

Fuse Clips
Trumbull Electric Mfg. Co.

Fuse Holders
Railway & Ind. Engrg. Co.

Fuse Plugs
Arrow Electric Co.
Harvey Hubbell, Inc.
Trico Fuse Mfg. Co.
Westinghouse Electric & Mfg. Co.

Fuse Puller Pliers
Grinder Sales Co.
Trico Fuse Mfg. Co.

Fuses
Colt's Patent Fire Arms Mfg. Co.
General Electric Co.
Trico Fuse Mfg. Co.
Renewable
Bussmann Mfg. Co.
Trico Fuse Mfg. Co.
Westinghouse Electric & Mfg. Co.
Non-Renewable
Trico Fuse Mfg. Co.

Gaskets
Sarco Co.

Gasoline Tanks & Pumps
Bowser & Co., S. F.

Gear & Wheel Pullers
Premier Electric Co.

Gear Cutting
Earle Gear & Machine Co.

Gears
Chicago Pulley & Shafting Co.
Cleveland Worm & Gear Co.
Dodge Mfg. Corp.
Earle Gear & Machine Co.
Falk Corp.
Foote Bros. Gear & Mach. Co.
General Electric Co.
Grant Gear Works, Inc.
Horsburgh & Scott Co., The
Jones Fdry. & Mach Co.,
Link-Belt Co.
Morse Chain Co.
Nuttall Co., R. D.
Palmer-Bee Co.
Philadelphia Gear Works
Smith, Winfield H.
Tool Steel Gear & Pinion Co.
Webster Mfg. Co.
Westinghouse Electric & Mfg. Co.
Whitney Mfg. Co.
Bevel
Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co.
Tool Steel Gear & Pinion Co.
Cast Iron, Steel, Bronze
Foote Bros. Gear & Mach. Co.
Composition
General Electric Co.
Westinghouse Electric & Mfg. Co.
Double Helical
De Laval Steam Turbine Co.
Foote Bros. Gear & Mach. Co.
Tool Steel Gear & Pinion Co.
Forged
Philadelphia Gear Works
Helical
De Laval Steam Turbine Co.
Falk Corp.
Foote Bros. Gear & Mach. Co.
Tool Steel Gear & Pinion Co.
General
Foote Bros. Gear & Mach. Co.
Herringbone
Falk Corp.
Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co., The
Micarta
Foote Bros. Gear & Mach. Co.
Rawhide
Foote Bros. Gear & Mach. Co.
Reducing
Cleveland Worm & Gear Co.
Foote Bros. Gear & Mach. Co.
Winfield H. Smith
Tool Steel Gear & Pinion Co.
Speed Reduction
Foote Bros. Gear & Mach. Co.
Spiral
Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co., The
Spur
Foote Bros. Gear & Mach. Co.
Tool Steel Gear & Pinion Co.
Worm
Cleveland Worm & Gear Co.
De Laval Steam Turbine Co.
Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co., The

Generating Sets
Allis-Chalmers Mfg. Co.
Crocker-Wheeler Co.
Diehl Mfg. Co.
General Electric Co.
Marble-Card Electric Co.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.

Generators
Allis-Chalmers Mfg. Co.
Burke Electric Co.
Crocker-Wheeler Co.
Diehl Mfg. Co.
Electro Dynamic Co.
General Electric Co.
Lincoln Electric Co.
Marble-Card Elec. Co.
Reliance Electric & Eng. Co.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.

Governors, Belt Tension
Bird Machine Co. (Pulmax Drive)

Grease Lubricators
Bowser & Co., S. F.

Grinders
Chicago Pulley & Shafting Co.
Martindale Electric Co.
Tool
Fafnir Bearing Co.

Grinding & Polishing
Strand & Co., N. A.

Grinding Appliances
Smidth & Co., F. L.

Grinding Compound
Oakite Products, Inc.

Ground—Ohmers
Herman H. Sticht & Co.

Grounding Devices
Dossert & Co.

Guards, Machinery
The Kirk & Blum Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 142.

Hanger Boxes
Chicago Pulley & Shafting Co.
Fafnir Bearing Co.
Wood's Sons Co., T. B.

Hangers
Wood's Sons Co., T. B.

Hangers, Line Shaft
American Pulley Co.
Chicago Pulley & Shafting Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Jones Fdry. & Mach. Co.,
Link-Belt Co.
Webster Mfg. Co.

Hangers, Safety Disconnecting
Thompson Electric Co.

Hangers, Shaft Ball Bearing
Chicago Pulley & Shafting Co.
Fafnir Bearing Co.
Wood's Sons Co., T. B.

Hardware, Pole Line
Ohio Brass Co.

Headlights, Arc & Incandescent
Ohio Brass Co.

Heating and Ventilating
American Blower Co.
Buffalo Forge Co.
The Kirk & Blum Mfg. Co.

Heating Devices, Industrial
General Electric Co.
Westinghouse Electric & Mfg. Co.
Wiegand Co., E. L.

Hoists, Electric
General Electric Co.
Link-Belt Co.
Shepard Elec. Crane & Hoist Co.

Hose
Air
Diamond Rubber Co.
Chemical
Diamond Rubber Co.
Fire
Diamond Rubber Co.

Humidifiers
American Blower Co.
Buffalo Forge Co.

Hydraulic Packings, Leather
Schieren Co., Chas. A.

Hydraulic Turbines
De Laval Steam Turbine Co.

Indicators, Speed
(See Tachometers).

Industrial Ovens
The Kirk & Blum Mfg. Co.

Instrument Transformers
American Transformer Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Instruments, Electrical
Graphic
General Electric Co.
Jewell Electrical Instrument Co.
Westinghouse Electric & Mfg. Co.
Indicating
Biddle, James G.
General Electric Co.
Jewell Electrical Instrument Co.
Taylor Instrument Co.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Corp.
Integrating
General Electric Co.
Jewell Electrical Instrument Co.
Westinghouse Electric & Mfg. Co.
Scientific and Testing Service
Biddle, James G.
General Electric Co.
Jewell Electrical Instrument Co.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Co.

Insulated Brackets
Fletcher Mfg. Co., The

Insulated Clamp Supports
Fletcher Mfg. Co., The

Insulated Clamps and Racks
Fletcher Mfg. Co., The

Insulating Material
Dolph Co., John C.
Asbestos
Johns-Manville Co.
Comp. Cloth and Paper
General Electric Co.
Mica Insulator Co.
Westinghouse Electric & Mfg. Co.
Compounds, Paints and Varnishes
General Electric Co.
Irvington Varnish & Insulator Co.
Mica Insulator Co.
Okonite Co.
Westinghouse Electric & Mfg. Co.
Fibre, Tape and Webbing
Irvington Varnish & Insulator Co.
Mica Insulator Co.
Moulded
Johns-Manville Co.
Mica Insulator Co.

Insulators
General Electric Co.
Irvington Varnish & Insulator Co.
Ohio Brass Co.
Square D. Co.
Westinghouse Electric & Mfg. Co.
Cleat Type
Railway & Ind. Engrg. Co.
Contact Rail
Ohio Brass Co.
Fibre
General Electric Co.
Pin
Ohio Brass Co.
Porcelain
Ohio Brass Co.
Strain
Ohio Brass Co.
Suspension
Ohio Brass Co.
Tape and Webbing
General Electric Co.
Mica Insulator Co.
Okonite Co., The
Westinghouse Electric & Mfg. Co.

Joints
Cable Splicing
Dossert & Co.

Ladles, Pouring
Rowell Mfg. Co.

Lamp Guards
Harvey Hubbell, Inc.
McGill Mfg. Co.
Westinghouse Electric & Mfg. Co.

Lamp Locks
Ren Mfg. Co.

Lamps
General Electric Co.
McGill Mfg. Co.
Trester Service Electric Co.
Westinghouse Electric & Mfg. Co.

Leather Specialties
Schieren Co., Chas. A.

Leveller Rolls
Tool Steel Gear & Pinion Co.

Lifting Magnets
Electric Controller & Mfg. Co.
Ohio Elect. & Cont. Co.

Lighting, Industrial
American Fixture Co.
Benjamin Electric Co.
General Electric Co.
Miller Co.
National Screw & Mfg. Co.
Westinghouse Electric & Mfg. Co.

Lightning Arresters
General Electric Co.
Westinghouse Electric & Mfg. Co.

Line Materials
Eureka Copper Prod. Corp.
Ohio Brass Co.

Liquid Storage & Distributing Systems
Bowser & Co., S. F.

Locking Electric Lamp Bulbs
Harvey Hubbell, Inc.

Locomotive Equip't, Elec.
Ohio Brass Co.

Lubricants
Standard Oil Co. (Ind.)

Lubricators, Force Feed
Bowser & Co., S. F.

Machinery, Mixing & Kneading
New England Tank & Tower Co.

Machines
Strand & Co., N. A.

Magnetic Separators
Electric Controller & Mfg. Co.
Ohio Electric & Controller Co.

Magnets, Lift
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
Ohio Elect. & Cont. Co.

Material Handling Equipment
Bassick Co.
Dodge Mfg. Corp.
Link-Belt Co.
Palmer-Bee Co.
Powell Pressed Steel Co.
Shepard Elec. Crane & Hoist Co.
Webster Mfg. Co.

Measuring Instruments, Precision
Norma Hoffmann Co.

Megohm Insulation Meters
Martindale Electric Co.

An OKONITE Product

OKOCORD

FLEXIBLE PORTABLE CORD & CABLE

Okonite Products

- OKONITE INSULATED WIRES AND CABLES
- VARNISHED CAMBRIC CABLES
- OKONITE INSULATING TAPE
- MANSON & DUNDEE FRICTION TAPES
- OKONITE CEMENT
- OKOCORD
- OKOLOOM

Okonite-Callender Products

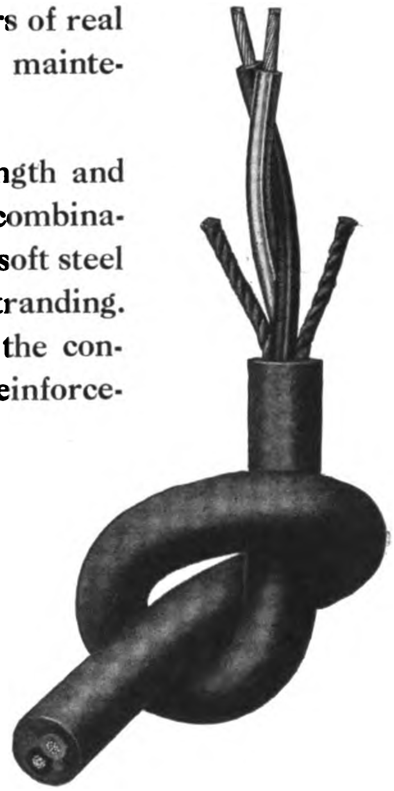
- IMPREGNATED PAPER CABLES
- SUPER-TENSION CABLES
- SPLICING MATERIALS

The best hard service flexible cord for rough usage!

A cord that will last, a cord that will resist moisture, oils, greases, acid and alkali fumes, a cord that will withstand the roughest usage, a cord that will give years of real service, a cord that means lower maintenance costs—that's OKOCORD.

Great flexibility, high tensile strength and full conductivity are insured by a combination of annealed tinned copper and soft steel wires assembled in a regular stranding. Seine twine threads twisted with the conductors form a highly efficient reinforcement. OKONITE insulation is used throughout.

Learn how Okocord cords and cables can lower maintenance costs for you. Write us for complete data.



THE OKONITE COMPANY.
THE OKONITE-CALLENDER CABLE COMPANY, INC.

Factories: Passaic, N. J. Paterson, N. J.

Sales OFFICES: NEW YORK CHICAGO PITTSBURGH ST. LOUIS ATLANTA BIRMINGHAM SAN FRANCISCO LOS ANGELES SEATTLE

Pettingell-Andrews Co., Boston, Mass.
Novelty Electric Co., Philadelphia, Pa. F. D. Lawrence Electric Co., Cincinnati, O.
Canadian Representatives: Engineering Materials Limited, Montreal
Cuban Representatives: Victor G. Mendoza Co., Havana

Megohmers—for insulation resistance measurements
Herman H. Sticht & Co.
Metal
Molding
Appleton Electric Co.
Monel
Breese Bros. Co.
Terne
Magnolia Metal Co.
Type
Magnolia Metal Co.
Metal Cleaners
Oakite Products, Inc.
Metal Washing
Oakite Products, Inc.
Metal Stampings
American Pulley Co.
Dodge Mfg. Corp.
The Kirk & Blum Mfg. Co.
Meters
General Electric Co.
Roller-Smith Co.
Westinghouse Electric & Mfg. Co.
Meter Testers
General Electric Co.
Westinghouse Electric & Mfg. Co.
Mica
Raw and Products
Mica Insulator Co.
Mica Under Cutting Machines
Hullhorst Micro Tool Co.
Mining Materials, Electric
Ohio Brass Co.
Motors
Allis-Chalmers Mfg. Co.
Baldor Electric Co.
Burke Electric Co.
Century Electric Co.
Crocker-Wheeler Co.
Diehl Mfg. Co.
Electro Dynamic Co.
General Electric Co.
Howell Electric Motors Co.
Imperial Electric Co.
Kimble Electric Co.
Lincoln Electric Co.
Marble-Card Electric Co.
Master Electric Co.
National Screw & Mfg. Co.
Ohio Elect. & Cont. Co.
Reliance Electric & Eng. Co.
Sturtevant Co., B. F.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.
Adjustable Speed
Kimble Electric Co.
Electric
Lincoln Electric Co.
Ohio Elec. & Controller Co.
Fractional H. P.
Ohio Elect. & Cont. Co.
Variable Speed
Kimble Electric Co.
Motors, New & Reconditioned
Trester Service Electric Co.
Motor Generators
Allis-Chalmers Mfg. Co.
Burke Electric Co.
Crocker-Wheeler Co.
Diehl Mfg. Co.
Ohio Elect. & Cont. Co.
Reliance Electric & Eng. Co.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.
Motor Repairs
Cleveland Armature Works
Motor Supports, Standard
Midwest Steel & Supply Co.
Moulding Machines
Osborn Mfg. Co.
Nut Setters
Strand & Co., N. A.
Ohmers—for low resistance measurements
Herman H. Sticht & Co.
Oil Cup
Gits Bros. Mfg. Co.
Oil Filters
Batch & Continuous
Bowser & Co., S. F.
Transformer & Switch
Bowser & Co., S. F.
Oil Gages
Gits Bros. Mfg. Co.
Oil Engines
Falk Corp.
Oil Purifiers, Centrifugal
De Laval Separator Co.
De Laval Steam Turbine Co.
Oil Storage & Distributing Systems
Bowser & Co., S. F.
Ovens, Electric
General Electric Co.
Westinghouse Electric & Mfg. Co.
Packing
Sarco Co.
Asbestos
Johns-Manville Co.

Piston
Diamond Rubber Co.
Pump
Diamond Rubber Co.
Paint Burner, Acetylene
Prest-O-Lite Co., Inc.
Paint Oil Storage Equipment
Bowser & Co., S. F.
Paints
Atlantic Drier & Varnish Co.
Sonneborn Sons, Inc., L.
U. S. Gutta Percha Co.
Panel Boards
Adam Electric Co., Frank
Benjamin Electric Co.
General Electric Co.
Trumbull-Vanderpoel Elec. Mfg. Co.
Westinghouse Eectric & Mfg. Co.
Paper Pulleys
Chicago Pulley & Shafting Co.
Pencils, Lead
American Lead Pencil Co.
Jos. Dixon Crucible Co.
Pillow Blocks, Adjustable
Wood's Sons Co., T. B.
Pinions
Foote Bros. Gear & Mach. Co.
Ramsey Chain Co.
Tool Steel Gear & Pinion Co.
Pipe Benders
Appleton Electric Co.
Plugs
Benjamin Electric Co.
General Electric Co.
Harvey Hubbell, Inc.
Westinghouse Electric & Mfg. Co.
Attachment
Arrow Electric Co.
Pneumatic Conveying Systems
Midwest Steel & Supply Co.
Porcelain Insulators; Pin, Suspension, Strain Contact, Rail, Special
Ohio Brass Co.
Potentiometers
Biddle, James G.
General Electric Co.
Westinghouse Electric & Mfg. Co.
Potheads
Railway & Ind. Engrg. Co.
Power Transmission Appliances
Allis-Chalmers Mfg. Co.
American Pulley Co.
Chicago Pulley & Shafting Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Foote Bros. Gear & Mach. Co.
Jones Fdry. & Mach. Co.,
Lewellen Mfg. Co.
Link-Belt Co.
Nuttall Co., R. D.
Palmer-Bee Co.
Reeves Pulley Co.
Smidth & Co., F. L.
Webster Mfg. Co.
Whitney Mfg. Co.
Wood's Sons Co., T. B.
Power Transmission Machy.
Medart Co.
Wood's Sons Co., T. B.
Power Transmission Supports
Midwest Steel & Supply Co.
Pressed Steel Parts
The Kirk & Blum Mfg. Co.
Powell Pressed Steel Co.
Pressure Blowers
American Blower Co.
Buffalo Forge Co.
Projectors, Floodlighting
Westinghouse Electric & Mfg. Co.
Protective Devices
Condit Elec. Mfg. Co.
General Electric Co.
Industrial Controller Co.
Railway Ind. & Engrg. Co.
Westinghouse Electric & Mfg. Co.
Pull Sockets
Harvey Hubbell, Inc.
Pullers, Gear & Wheel
Premier Electric Co.
Pulleys
American Pulley Co.
Chicago Pulley & Shafting Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Jones Fdry. & Mach Co.,
Link-Belt Co.
Medart Co.
Reeves Pulley Co.
Smith, Winfield H.
Webster Mfg. Co.

Cast Iron
Wood's Sons Co., T. B.
Motor
Wood's Sons Co., T. B.
Pull Sockets
Arrow Electric Co.
Pulverizing Appliances
Smidth & Co., F. L.
Pumping Machinery
Buffalo Forge Co.
Pumps
Boiler Feed
De Laval Steam Turbine Co.
Centrifugal
Allis-Chalmers Mfg. Co.
De Laval Steam Turbine Co.
Fire
De Laval Steam Turbine Co.
General Service
De Laval Steam Turbine Co.
Reciprocating
Allis-Chalmers Mfg. Co.
Self-Measuring
Bowser & Co., S. F.
Stock
De Laval Steam Turbine Co.
Punching Machinery
Buffalo Forge Co.
Purifiers
Insulating Oil
Hydroil Sales Corp.
Lubricating Oil
Hydroil Sales Corp.
Pyrometers
Taylor Instrument Co.
Rail Bonds
Ohio Brass Co.
Rail Grippers
Rowell & Son, G. D.
Recorders, Temperature and Pressure
Taylor Instrument Co.
Rectifiers
General Electric Co.
Westinghouse Electric & Mfg. Co.
Reels, Extension
Appleton Electric Co.
Reflector Hangers
Thompson Electric Co.
Reflectors
Benjamin Electric Co.
Harvey Hubbell, Inc.
Miller Co.
National Screw & Mfg. Co.
Thompson Electric Co.
Westinghouse Electric & Mfg. Co
Refrigerating Machinery
Triumph Electric Co.
Registering Measures
Pipe Line
Bowser & Co., S. F.
Regulators
Sarco Co.
Induction Voltage
General Electric Co.
Westinghouse Electric & Mfg. Co.
Pressure
Electric Controller & Mfg. Co.
Speed
Cutler-Hammer Mfg. Co.
Industrial Controller Co.
Temperature and Pressure
Electric Controller & Mfg. Co.
Sarco Co.
Taylor Instrument Co.
Relays, Air Pressure
Railway & Ind. Engrg. Co.
Relays, Overload
Allen-Bradley Co.
Repair Data
McGraw-Hill Book Co.
Resistance Units
General Electric Co.
Railway & Ind. Engrg. Co.
Westinghouse Electric & Mfg. Co.
Rheostats
Allen-Bradley Co.
Biddle, J. G.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Electric & Mfg. Co.
Rivets
Harvey Hubbell, Inc.
National Screw & Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 142.

Roller Chains
Link-Belt Co.
Whitney Mfg. Co.
Roofing
Sonneborn Sons, Inc., L.
Rope, Wire Transmission, Hoisting & Haulage
Williamsport Wire Rope Co.
Rosettes
Arrow Electric Co.
Harvey Hubbell, Inc.
Rotary Files
Strand & Co., N. A.
Rust Preventatives
Oakite Products, Inc.
Saws
American Saw & Mfg. Co.
Schools
Ft. Wayne Correspondence School
Screw Drivers
American Saw & Mfg. Co.
Strand & Co., N. A.
Screws
Cap & Set
Allen Mfg. Co.
National Screw & Mfg. Co.
Machine
Harvey Hubbell, Inc.
National Screw & Mfg. Co.
Second-Hand Apparatus
(See Searchlight Section)
Gregory Electric Co.
Shafts, Flexible
Strand & Co., N. A.
Shapes, Pressed Steel
American Pulley Co.
The Kirk & Blum Mfg. Co.
Shearing Machines
Buffalo Forge Co.
Shock Absorbers, Automobile
Detroit Steel Products Co.
Silent Chain Drives
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.
Slotters, Commutator
Green Equipment Co.
Hullhorst Micro Tool Co.
Martindale Electric Co.
Smoke Stacks
Chicago Bridge & Iron Co.
Sockets and Receptacles
Arrow Electric Co.
Benjamin Electric Co.
General Electric Co.
Harvey Hubbell, Inc.
Miller Co.
Westinghouse Electric & Mfg. Co.
Solder
Allen Co., L. B.
Magnolia Metal Co.
Soldering Compounds
Allen Co., L. B.
McGill Mfg. Co.
Soldering Torches
Prest-O-Lite Co., Inc.
Space Heaters
Westinghouse Electric & Mfg. Co.
Wiegand Co., Edwin L.
Special Steel Sections
Midwest Steel & Supply Co.
Speed Indicators
Herman H. Sticht & Co.
Speed Reducers
Cleveland Worm & Gear Co.
Falk Corp.
Foote Bros. Gear & Mach. Co.
Grant Gear Works, Inc.
Horsburgh & Scott Co., The
Jones Fdry. & Mach. Co.,
Morse Chain Co.
Palmer-Bee Co.
Philadelphia Gear Works
Smith, Winfield, H.
Tool Seel Gear & Pinion Co.
Webster Mfg. Co.
Whitney Mfg. Co.
Worm Gear
Cleveland Worm & Gear Co.
Speed Reducers (Chain)
Link-Belt Co
Morse Chain Co.
Whitney Mfg. Co.
Speed Transformers
De Laval Steam Turbine Co.
Springs, Automobile
Detroit Steel Products Co.
Sprockets
Chicago Pulley & Shafting Co.
Diamond Chain & Mfg. Co.
Dodge Mfg. Corp.
Grant Gear Works, Inc.
Link-Belt Co.
Morse Chain Co.
Ramsey Chain Co.
Philadelphia Gear Works
Whitney Mfg. Co.
Starters, Motor
(See Controllers)
Stator Horns or Drift
Grinder Sales Co.

Steam Specialties
Johns-Manville Co.
Steam Turbines
De Laval Steam Turbine Co.
Steel Metal Parts
Breese Bros. Co.
Steel Plate, Const.
Chicago Bridge & Iron Co.
Steel Stringers
Midwest Steel & Supply Co.
Stones, Commutator
Green Equipment Co.
Martindale Electric Co.
Strapping, Leather
Schieren Co., Chas. A.
Strip Heaters
Westinghouse Electric & Mfg. Co.
Wiegand Co., Edwin L.
Strippers, Paint, etc.
Oakite Products, Inc.
Substations, Outdoor
General Electric Co.
Railway & Ind. Engrg. Co.
Westinghouse Elec. & Mfg. Co.
Supplies, Electrical
General Electric Co.
Harvey Hubbell, Inc.
Westinghouse Elec. & Mfg. Co.
Supplies, Railway
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Switchboard Supplies
Adam Electric Co., Frank
General Electric Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Switchboards
Adam Electric Co., Frank
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Condit Electric Mfg. Co.
General Electric Co.
Trumbull-Vanderpoel Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Asbestos Wood
Johns-Manville Co.
Battery Charging
Allen-Bradley Co.
Switches
Eureka Copper Prod. Corp.
Air Brake and Pole Top
Condit Electrical Mfg. Co.
General Electric Co.
Railway & Ind. Engrg. Co.
Union Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Automatic
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Sundh Electric Co.
Union Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Conduit Box
McGill Mfg. Co.
Disconnecting
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Railway & Ind. Engrg. Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Float
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.
Fuse
Adam Electric Co., Frank
Condit Electrical Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Instrument Cutout
Railway & Ind. Engrg. Co.
Knife
Adam Electric Co., Frank
Condit Electrical Mfg. Co.
Cutler-Hammer Mfg. Co.
Cutter Co.
General Electric Co.
Trumbull Electric Mfg. Co.
Trumbull-Vanderpoel Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Magnetic
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Rowan Controller Co.
Sundh Electric Co.
Westinghouse Elec & Mfg. Co.

Oil
Allen-Bradley Co.
Condit Electrical Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Push Button
Arrow Electric Co.
Cutler-Hammer Mfg. Co.
Harvey Hubbell, Inc.
McGill Mfg. Co.
Remote Control
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Rowan Controller Co.
Sundh Electric Co.
Westinghouse Elec. & Mfg. Co.
Safety Enclosed
Adam Electric Co., Frank Mfg. Co.
Colt's Patent Fire Arms
General Electric Co.
Square D Co.
Trumbull Electric Mfg. Co.
Trumbull-Vanderpoel Elec. Mfg. Co.
Westinghouse Elec. & Mfg.
Series
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Snap
Arrow Electric Co.
Cutler-Hammer Mfg. Co.
Harvey Hubbell, Inc.
McGill Mfg. Co.
Surface and Flush
General Electric Co.
Trumbull Electrical Mfg. Co.
Westinghouse Elec. & Mfg Co.
Time
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Synchronous Motor Starters
Allen-Bradley Co.
Electric Controller & Mfg. Co.

Synchroscopes
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.

Weston Electrical Ins't. Corp.

Systems
Filtering
Bowser & Co., S. F.
Lubricating
Bowser & Co., S. F.
Oil, Gasoline & Liquid
Bowser & Co., S. F.
Storage & Distributing
Bowser & Co., S. F.

Tachometers
Biddle, James G
Herman H. Sticht & Co.
Westinghouse Elec. & Mfg. Co.

Tags
Denney Tag Co.

Tanks
New England Tank & Tower Co.

Tanks, Elevated Oil, Storage, Water & Sprink
Chicago Bridge & Iron Co.

Tanks & Vats
New England Tank & Tower Co.

Tap Extension
Allen Mfg. Co.

Tape
Splicing
Okonite Co.

Tape & Webbing
Irvington Varnish & Insulator Co.
Mica Insulator Co.
Okonite Co., The

Testing
Oils, Dielectric
Hydroil Sales Corp.

Testing Apparatus
American Transformer Co.
Biddle, James G.
Colt's Patent Fire Arms Mfg. Co.
Electric Tester Co.
General Electric Co.
Roller-Smith Co.
Square D Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't. Corp.

Testers, Voltage
Martindale Electric Co.

Thermometers, Indicating & Recording
Sarco Co.
Taylor Instrument Co.

Timing Chains
Whitney Mfg. Co.

Tools
American Saw & Mfg. Co.
Armstrong Bros. Tool Co.
Klein & Sons, Mathias
Coil Winding
Grinder Sales Co.

Torches, Blow
Prest-O-Lite Co., The

Transformer, Oil Purifiers
Centrifugal
De Laval Separator Co.

Transformers
Allis-Chalmers Mfg. Co.
American Transformer Co.
Burke Electric Co.
General Electric Co.
Kuhlman Electric Co.
Sorgel Electric Co.
Trester Service Electric Co.
Westinghouse Elec. & Mfg. Co.

Transmission, Power
Bird Machine Co. (Pulmax Drive)

Transmissions, Variable Speed, Ball Bearing
Lewellen Mfg. Co.

Traps, Steam & Radiator
Johns-Manville Co.
Sarco Co.

Tree Wire
Okonite Co.
Simplex Wire & Cable Co.

Trolley and Sheet Wheels
Eureka Copper Products Corp.

Trolley Line Materials
Ohio Brass Co.

Trolleys, I-beam
Palmer-Bee Co.

Truck Castors
Bassick Co.

Trucks & Tractors
Industrial Electric
Elwell-Parker Electric Co.

Turbines, Steam
Buffalo Forge Co.

Undercutting Machines, Mica
Grinder Sales Co.
Hullhorst Micro Tool Co.

Underflow Duct Systems
Johns-Manville Co.

Valves
Sarco Co.

Valves, Brass, Gas, Water, Steam
Ohio Brass Co.

Variable Speed Transmission
Mica Insulator Co.
Reeves Pulley Co.

Varnish
Atlantic Drier & Varnish Co.

Varnish, Insulating
Dolph C. John C.

Varnishes, Cable
Dolph C. John C.

Ventilators
American Blower Co.
Buffalo Forge Co.
Kirk & Blum Mfg. Co.
Okonite Co., The
Simplex Wire & Cable Co.

Waterproofing Materials
Sonneborn Sons, Inc., L.

Waste Cleaner & Oil Reclaimers
Oakite Products, Inc.

Welders
Arc
Burke Electric Co.
General Electric Co.
Lincoln Electric Co.
Westinghouse Elec. & Mfg. Co.
Automatic Electric
Lincoln Electric Co.
Electric
Lincoln Electric Co.

Welding Machines
Burke Electric Co.
General Electric Co.
Ohio Brass Co.
Westinghouse Elec. & Mfg. Co.

Wheels, Polishing
Osborn Mfg. Co.

Wheels & Harps, Trolley
Ohio Brass Co.

White Metals
Magnolia Metal Co.

Windows, Steel
Detroit Steel Products Co.

Wire Insulation Strippers
Grinder Sales Co.

Wires and Cables
Asbestos Covered
American Steel & Wire Co.
Rockbestos Products Corp.
Bare Copper
American Steel & Wire Co
Rome Wire Co.

Enameled
Maring Wire Co.
Insulated
American Steel & Wire Co.
Indiana Rubber & Insulated Wire Co.
Okonite Co., The
Simplex Wire & Cable Co.
Tubular Woven Fabric Co.
Magnet
American Steel & Wire Co.
Maring Wire Co.
Rockbestos Prod. Corp.
Rome Wire Co.
Magnet, Enameled
Rockbestos Prod. Corp.
Rome Wire Co.
Reinforced, Flexible
American Steel & Wire Co.
Rome Wire Co.
Simplex Wire & Cable Co.
Tubular Woven Fabric Co.
Resistance
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Rope
American Steel & Wire Co.
Rubber Covered and Weatherproof
American Steel & Wire Co
Indiana Rubber & Insulated Wire Co.
Okonite Co., The
Rockbestos Prod. Corp.
Rome Wire Co.
Simplex Wire & Cable Co.
Tubular Woven Fabric Co
Steel
American Steel & Wire Co.
Underground (Cable)
American Steel & Wire Co.
Rome Wire Co.
Varnished Cambric
Okonite Co.
Welding
American Steel & Wire Co.
Lincoln Electric Co.

Wiring Materials
Trester Service Electric Co.

Wood Floor Preservative
Sonneborn Sons, Inc., L.

Woodworking Machines
Parks Woodworking Machine Co.

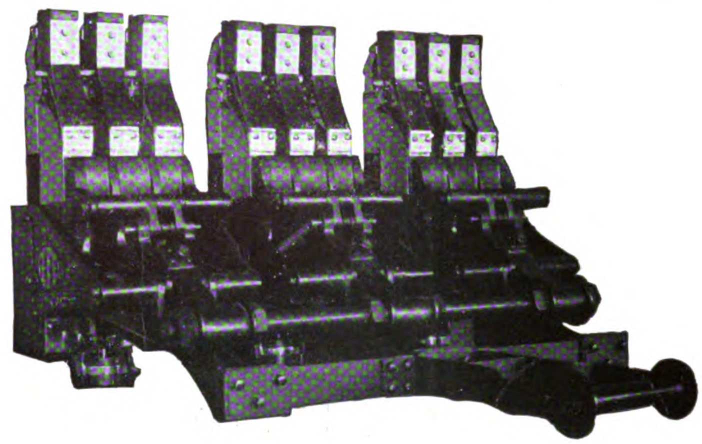
Worm Gears
Cleveland Worm & Gear Co.

Wrenches
Lowell Wrench Co.
Ratchet
Lowell Wrench Co.

ALPHABETICAL INDEX TO ADVERTISERS

Immersed in AIR

for SAFETY AND RELIABILITY



A PROMINENT CHICAGO INSTALLATION

A 5000 ampere I-T-E type L G Circuit Breaker for 600 volts or less alternating current service. This breaker is equipped with Overload, Dalite (direct acting inverse time limit), and Autoite (non-closable on overload) features.

I-T-E AIR BREAK has definite advantages not present in the oil breaker

1. No oil—to leak, carbonize, burn or explode—Just air.
2. No tanks to conceal anything—or the lack of it.
3. No cells—nothing which needs or deserves to be imprisoned—Just a faithful and efficient servant.
4. Inherent simplicity—with resulting low cost of installation and maintenance.

THE CUTTER COMPANY—*EST. 1888*—505 N. 19th STREET—PHILADELPHIA

CUTTER

U-RE-LITE ⸱ ⸱ ⸱ I-T-E CIRCUIT BREAKERS